POWER PLANT ENGINEERING

Established Over 32 Years

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Well! Well!

JUST SEE what we have here—a flock of oil wells grazing in somebody's back yard, perhaps the sunken garden of some astute politician, who can tell? But never mind that angle of the subject, enough has been said on it without our becoming involved. It is with considerable hesitancy, in fact, that we can bring ourselves even to mention the subject of oil, for oil is in bad repute, particularly in the higher branches of politics, where, paradoxical as it may sound, it has caused much friction.

To engineers, familiar with the action of oils, the reason for this unfortunate state of affairs is, of course, quite obvious. Oil, especially the crude variety, and politics does not mix any more than does oil and water. Indeed, had the politicians—but there we go again, we cannot forget the politicians, it seems—what we wanted to say was that when oil and water come together, as they often do in a turbine lubricating system, they tend to emulsify. There are, however, different kinds of emulsification, some of which are more serious than others. In a turbine lubricating system, the emulsification may be either permanent or temporary, depending upon the character of the oil and, as stated in an article in this issue by H. L. Kauffman, it is the permanent emulsification that we as engineers must avoid. Mr. Kauffman who is a chemist presents many interesting facts, not only in regard to emulsification of oil but on other aspects of turbine lubrication as well. Many engineers, we gather from reading this article are as little versed in the technique of handling oils as are some politicians and Mr. Kauffman's remarks, although they may sting a little, are, nevertheless, sound and if taken in the proper spirit should be of value to any engineer.

Mullett St. Heating Plant Serves Municipal Group

NEW BOILER PLANT SUPPLIES STEAM TO EIGHT MUNICIPAL BUILDINGS IN DETROIT, MICH., AT LOW COST; IT WAS DESIGNED FOR COMPACTNESS, LOW FIRST COST AND CONTINUITY OF SERVICE

PRESENT-DAY PRACTICE in power plant design does not often involve the problem of saving space in laying out a plant that is to be housed in a building entirely separate from those it serves. In the hotel, public building or institution, as well as on board ship, space is at a premium, of course. In all cases, economy is the principal determining factor. But in the design of the Mullett St. Heating Plant, built by the City of Detroit, Mich., in 1926, to supply steam to a group of eight municipal buildings, it was necessary not only to design a plant that would make cheap steam but also to arrange the necessary equipment compactly, as the city had only a small lot of land available on which to build the plant. Low first cost, continuity of service and simplicity were demanded in addition to compactness and economy of operation.

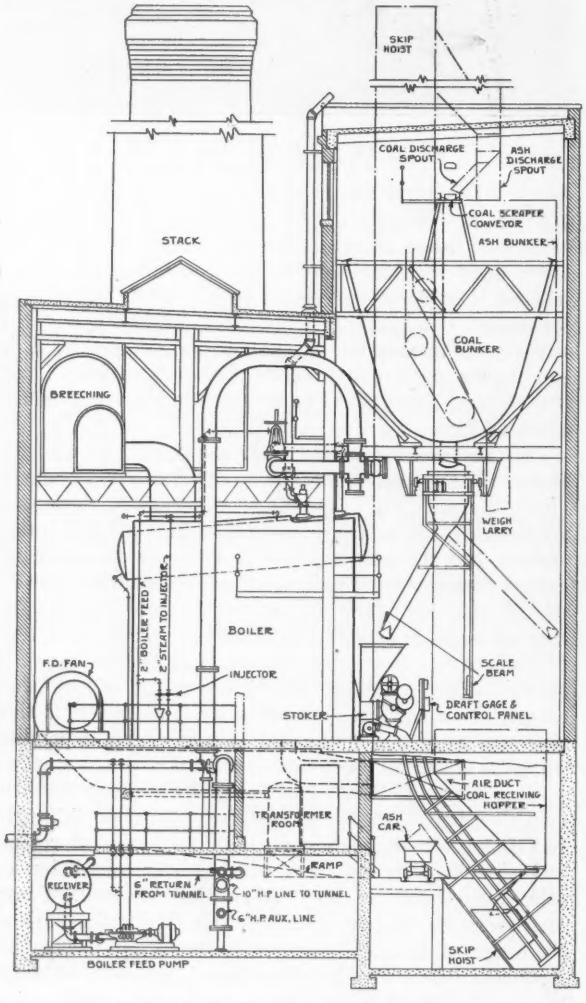


FIG. 1. CROSS-SECTION THROUGH MULLETT ST. PLANT SHOWING COAL AND ASH HANDLING EQUIPMENT, PUMP ROOM AND BOILER ARRANGEMENT

These objects have been attained, in the opinion of the City of Detroit's engineers. A study of the accompanying cost tabulations and illustrations will show what has been accomplished. In a space 99 ft. long and 50 ft. wide, a boiler house has been built containing five stoker-fired boilers with a total capacity of 1535 b.hp., with settings designed for good operation at 200 per cent of rating, complete coal and ash handling equipment, pumps and fans and a 150-kw. steam turbo-generator for emergency service. This boiler plant supplies dry saturated steam at 125 lb. pressure through a 600-ft. steam line, running in a tunnel, to the various

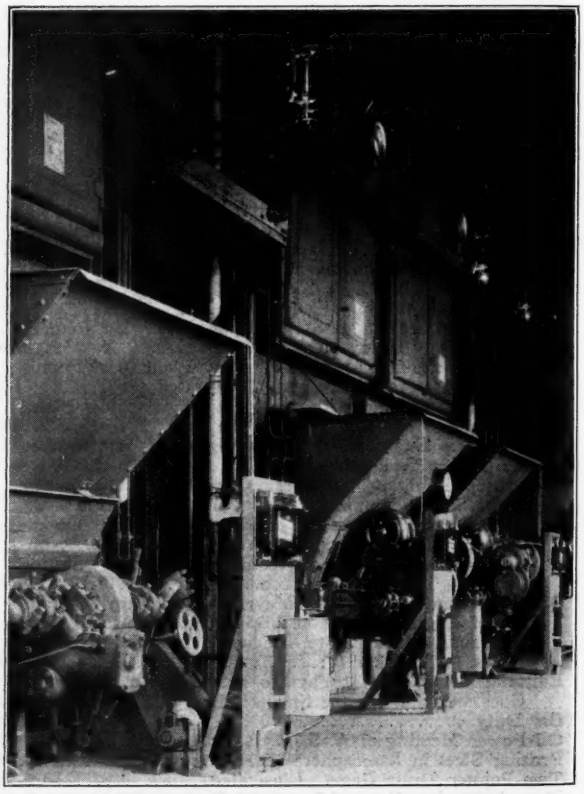


FIG. 2. EACH STOKER-FIRED BOILER IS HANDLED FROM THE CONTROL BOARD IN FRONT OF IT

buildings as listed on Table II. These have a total of 160,000 sq. ft. of radiating surface. All electric power for these buildings and for the boiler plant auxiliary motors is supplied by the Detroit municipal power system, which is fed by the new Morrell St. generating station. The turbo-generator at Mullett St. is intended to be thrown into service, to operate the auxiliaries and boiler house lights, only in case of an interruption of service on the main system. Mullett St. plant, therefore, is primarily a heating plant.

Considering this fact, the average steam cost of $0.00085 per lb. or $0.85 per thousand pounds for five

months, July to November, 1927, shown in Table I, is of interest. It should be noted that this period includes only two months when full heating load was on; the total steam costs for September were $0.63 per thousand pounds and for November $0.56. These costs for live steam only are considered by the City of Detroit to compare favorably with steam costs of industrial plants using exhaust steam for heating and also with the costs of many public utility district heating plants. As shown on Table II, steam supplied to the various buildings is charged at $1.30 per thousand pounds less 10 per cent on amounts of 100,000 lb. and over. This is not an actual charge to each department, since the plant is operated by money received from direct taxation. No money is collected from city departments. On this basis, which seems reasonable to the city in view of the price that would otherwise have to be paid for steam, the operation of the Mullett St. plant results in a neat profit for the city, according to the accompanying cost reports.

Instruments Provided for Complete Records

Credit for the satisfactory operation of Mullett St. heating plant is divided between the designing engineers, E. R. Little & Co., Inc., and the chief operating engineer, C. H. Menmuir. The design provides adequate equipment for the services demanded, with sufficient instruments for obtaining complete records of operation, yet without frills or undue elaboration of the plant. The chief engineer, by his effective use of these records and his care in operating the equipment and keeping it in good condition, has been successful, it is felt, in carrying out the purpose of the designers. The plant is under the jurisdiction of the Public Lighting Commission of the City of Detroit, of which Frank Mistersky is superintendent.

As noted above, economy of space was an important consideration in designing the Mullett St. plant. It was

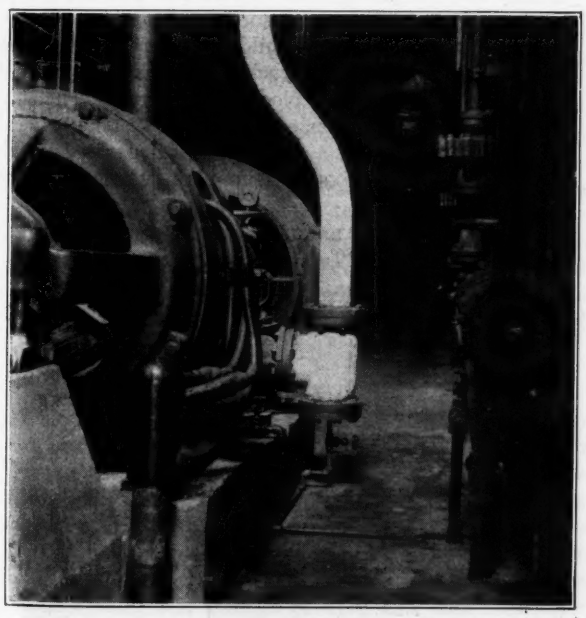
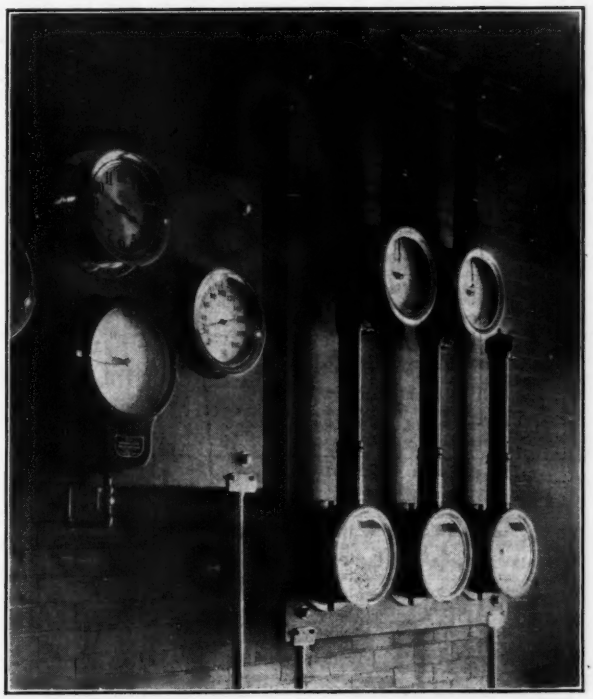


FIG. 3. IN THE AISLE BEHIND THE BOILERS, AUXILIARIES ARE SET. IN FOREGROUND IS 150-KW. EMERGENCY TURBO-GENERATOR; FORCED DRAFT FAN BEHIND IT



INSTRUMENTS IN CHIEF ENGINEER'S OFFICE

built on a 120 ft. by 50-ft. lot; another similar lot of land adjoined it and the city has acquired this second lot for use if it becomes necessary to increase the steam capacity of the plant. Accordingly arrangement of equipment was made with the idea that this might be done. The coal handling equipment, laid out with this end in view, runs longitudinally over the firing aisle so that if more boilers are added later on the other side, the weigh larry can feed to both sides. Main steam piping and boiler feed lines are also installed so that a second battery of boilers can be easily connected.

Five horizontal longitudinal drum water tube boilers were installed, each with heating surface of 3070 sq. ft. These make saturated steam at 125 lb. gage pressure and are fired by 4-retort, 17-tuyere, underfeed stokers, with solid refractory settings. Settings and stokers are designed so that the boilers can be operated with little difficulty for long periods at 200 per cent of rating. Three of the boilers and stokers are new; the other two units were removed from the old municipal steam plant and reconditioned for use here.

Coal-Handling Equipment

Five boilers were selected, set in two pairs with the fifth separate, to give flexibility in handling the load, especially in summer when the steam demands are for cooking, laundry work and some laboratory work. Besides this, it was desired to use the two rebuilt boilers and stokers. Under most conditions, when the heating load is on, it is carried by three boilers, with one held in reserve and one down for cleaning. Average steam load is between 50,000 and 60,000 lb. per hr. during the heating season. Evaporation for such periods averages between 9 and 10 lb. water per pound of coal, according to the plant records.

In the limited space available, it was somewhat of a

TABLE I. OPERATING EXPENSES, MULLETT ST. HEATING PLANT, DETROIT, MICH., JULY TO NOVEMBER, 1927

Production - Operation	July	August	September	October	November	
Superintendence	$ 250.00	$ 250.00	$ 250.00	$ 250.00	$ 250.00	
Wages - Coal handlers	588.67	732.69	575.30	589.59	752.42	
" - Fireman & assistants	581.94	747.10	613.86	614.88	768.60	
" - Care of Buildings & Grounds	69.75	78.00	84.75	80.25	85.50	
Fuel - Coal	951.80	861.19	1,178.94	3,147.80	396.16	
Water				45.78		
Station Supplies & Expenses						
For Boilers and Apparatus	214.98	76.19	43.88	47.02	81.30	
For Experimental and Routine Testing		2.50				
For Buildings and Grounds	2.81	11.87	8.89	.60	6.75	
Total Production - Operation	2,659.95	2,759.54	2,755.62	4,775.92	6,340.73	
Production - Maintenance						
Repairs - Station Buildings				1.50		
Repairs - Steam Equipment						
Boilers	135.17	84.38	105.62	32.00	70.56	
Auxiliary and Draft Equipment	3.50	31.12	26.50	22.52	6.40	
Stokers		6.00			6.40	
Coal and Ash Handling Equipment		3.75		6.40	25.60	
Piping	6.80	77.79	32.28	31.45	36.65	
Electrical Bus & Switching Equipment			1.50			
Total Production - Maintenance	145.47	203.04	165.90	93.87	145.61	
Distribution - Operation						
Wages - Patrolling and Inspecting Steam Mains	51.40	74.10		58.00	148.70	
Distribution - Maintenance						
Repairs - Steam Heating Tunnels	28.42	12.82	121.47	7.32	38.19	
General Expense						
General Office Expense	56.16	70.97	72.24	27.83	44.51	
Insurance	12.51	12.51	12.51	12.51	12.51	
Relief Dept. Expense	117.12	234.24	93.96			
Total General Expense	185.79	317.72	178.71	40.34	57.02	
						Total
Total (Cash Cost)	$3,071.03	$3,367.22	$3,221.70	$4,975.45	$6,730.25	$21,365.65
Steam Produced - Pounds	3,727,332	3,310,146	4,497,831	11,685,213	16,165,863	39,386,385
Cost per pound	.00082	.00102	.00072	.00043	.00042	.00054
Renewal and Replacement Expense	1,065.03	1,065.03	1,065.03	1,065.03	1,065.03	5,325.15
Interest on Funded Debt	1,331.25	1,331.25	1,331.25	1,331.25	1,331.25	6,656.25
Total Expenses	5,467.31	5,763.50	5,617.98	7,371.73	9,126.53	33,347.05
Total Cost per Pound of Steam	.00141	.00174	.00125	.00063	.00056	.00085
Revenues						
Sale of Cinders		191.97				191.97
Sale of Steam (Year 1926-27)	9,516.33					9,516.33
Total Revenue	$9,516.33	$ 191.97				$9,708.30

TABLE II. AMOUNTS OF STEAM USED BY BUILDINGS, SERVED FROM MULLETT ST. PLANT, FOR FEBRUARY AND MARCH, 1927, TAKEN FROM VENTURI METER

BUILDINGS SERVED BY MULLETT ST. PLANT	PERCENTAGES	TOTAL LBS. OF STEAM USED BY EACH DEPT.		TOTAL COST 1.30 per M less 10%	
		Feb. '27	Mar. '27	Feb. '27	Mar. '27
Municipal Court	22.3	3,953,030	3,995,340	$4625.55	$4674.55
Police Headquarters Receiving Hospital)	24.6	4,360,740	4,407,420	5102.07	5156.68
Kitchen & Laundry) Addition)	34.1	6,044,770	6,109,470	7072.38	7148.08
County Jail	3.93	696,650	704,110	815.08	823.81
Central Fire) Alarm Station)	1.58	280,080	283,080	327.69	331.20
City Service Bldg.	1.84	326,170	329,660	381.62	385.70
Board of Health	.95	168,400	170,210	197.03	199.15
College of Medicine	10.70	1,896,760	1,917,050	2219.20	2242.95
	100.00	17,726,590	17,916,340	$20740.12	$20962.12

TABLE III. MONTHLY STEAM AND COAL COSTS FOR 4 MO. AT MULLETT ST. HEATING PLANT

	TOTAL STEAM POUNDS	TOTAL COST	COST PER M POUNDS
1926 December	20,650,000	$8,265.86	.40029
1927 January	20,760,000	6,942.23	.33440
1927 February	17,726,590	6,252.73	.35273
1927 March	17,916,340	6,669.53	.37226
TOTAL	77,052,930	$28,130.35	.36508

COAL ON HAND MARCH 1st.	681,040 LBS.	@ $4.6009 TON	$1566.70
COAL RECEIVED BY TRUCK	1,944,570 "	4.60 "	4472.51
TOTAL COAL	2,625,610 "	4.60023 "	6039.21
COAL FIRED	1,929,604 "	4.60023 "	4438.31
COAL ON HAND APRIL 1st	696,006 "	$4.60023 "	$1,600.90

problem to provide storage space for coal, which must be brought to the plant by truck. This problem was solved by placing a steel bunker of 475 t. capacity directly over the firing aisle. To fill this bunker, a 35-t. per hr. skip hoist is used, loaded automatically from a hopper at the front of the building. Here a recess was provided so that the coal trucks can back right into it when unloading, to avoid blocking the street. The skip hoist unloads to a scraper conveyor that distributes coal to the bunker, whence a 2000-lb. motor-operated weigh larry takes it to the stoker hoppers. Ash from the

TABLE IV. TRIAL BALANCE, NOVEMBER 30, 1927, MULLETT ST. HEATING PLANT

City of Detroit - Appr. for Heating Plant		$ 89,933.60	
City Treasurer			$ 39,693.35
Coal		2,130.31	
Board of Education		9,516.33	
Unfinished Plant		9,111.24	
Heating Plant Land	363-A	47,890.30	
Improvements to Land	364-A	5.01	
Heating Plant Buildings	364-B	94,460.79	
Heating Plant Equipment	365-A	155,561.71	
Steam Distribution System	366-A	60,852.00	
Miscellaneous Equipment Heating	368-A	323.98	
Miscellaneous Const. Expenditures	369-A	30,363.78	
Interest During Construction		12,797.00	
Prepaid Accounts		287.78	
Operating Expenses		21,365.65	
Renewal and Replacement Expense		5,325.15	
Interest on Funded Debt		6,656.25	
Appropriation - Capital Costs			2,890.10
" - Operation and Maintenance			60,670.16
" - Deficits			7,545.01
General Municipal Bonds 4½%			355,000.00
Audited Vouchers			346.60
Accounts Payable			164.18
" " P.L.C.			1,400.12
Renewal and Replacement Reserve			14,155.40
Interest Accrued on Funded Debt			6,656.25
Operating Revenues			9,708.30
City of Detroit - Net Investment			47,361.41
		$545,580.88	$545,580.88

furnaces is dumped into an industrial car and loaded into the skip hoist to be elevated to an ash bunker just over the coal unloading space. Thus the ash can be spouted into the coal delivery trucks for removal after the trucks have unloaded coal to the hopper below.

Two motor-driven forced draft fans, one of 30,000-c.f.m. capacity and one of 22,000-c.f.m., supply combustion air for the stokers, flue gas passing out through a 9 ft. 6-in. by 140-ft. radial brick chimney. These fans, together with the emergency turbo-generator and a 100-c.f.m. air compressor, are set on the main floor behind the boilers, Figs. 1 and 3.

rent motors; these include stoker motors, which have a four-speed control. The latter are controlled from individual boards in front of each stoker, Fig. 2; on these boards are mounted also the draft gages and motor controllers for forced draft fans. Water columns are illuminated and are easily seen from the firing floor and water level is automatically controlled.

In the chief engineer's office are mounted two gage boards, one carrying five CO_2 recorders for the five boilers, the other carrying pressure indicating gages and recorders. Here also is mounted the recorder of a Venturi meter that measures total amount of water fed

Principal Equipment in Mullett St. Heating Plant, Detroit, Mich.

General

Location.....Detroit, Michigan
Service .....
....Steam to eight municipal buildings
Rated capacity.....
....1535 b.hp.; 46,050 lb. steam per hr.
Built for.....Public Lighting Commission, Frank Mistersky, Gen'l Supt.; L. J. Schrenk, Plant Supt.
Chief operating engineer..C. H. Menmuir
Designing engineers..E. R. Little Co., Inc.
Consulting architects..Donaldson & Meier
Contractor .....
..Pittelkow Heating & Engineering Co.

Boilers and Stokers

Boilers.....Heine Boiler Co.
Type....Straight tube longitudinal drum
Number.....5 (3 new, 2 rebuilt)
Heating surface, each.....3070 sq. ft.
Heating surface per sq. ft. grate area
..... 47.5
Working pressure, gage.....150
Stokers.....American Engineering Co.
Type .....
..Taylor, 4-retort, 17-tuyere, underfeed
Number.....5 (3 new, 2 rebuilt)
Grate, area.....65 sq. ft.
Drive.....A.c. motor, 4-speed control
Coal burned....Bituminous, 13,500 B.t.u.

Draft Equipment

Forced draft fans.....1 new American Blower Co., 1 rebuilt Buffalo Forge Co.
Total capacity..52,000 c.f.m. at 5 in. water
Drive .....A.c. motor
Chimney .....Alphons Custodis Chimney Construction Co.
Type .....Perforated radial brick
Size...9 ft. 6 in. I. D. at top; 140 ft. high
Breeching.....Pittelkow Htg. Co.
Breeching lining...Holdtite Insulating Co.

Coal and Ash Handling Equipment

Skip hoist and scraper conveyor.....
.....R. H. Beaumont Co.
Capacity .....35 t. per hr.
Hoppers and bunkers..R. H. Beaumont Co.
Weigh larry.....R. H. Beaumont Co.
Capacity.....2000 lb., motor driven
Ash hoppers and gates.....
.....R. H. Beaumont Co.

Turbo-Generator and Pumps

Turbo-generator .....
.....Westinghouse Elec. & Mfg. Co.
Type.....Geared, overhung turbine rotor
Capacity.....150-kw., 80 per cent p.f., 3600-r.p.m., 220-v., 3-ph., 60-cycle
No vacuum pumps.
Boiler feed pumps.....
.....De Laval Steam Turbine Co.
Type.....Two centrifugals
Capacity, each.....150 g.p.m.
Drive.....A.c. motors
Governors .....Copes
Sump pumps.....Union Steam Pump Co., Kerr Mach. Co.

Other Equipment

Auxiliary motors.....
.....Westinghouse Elec. & Mfg. Co.
Type.....A.c., 220-v., 3-phase, 60-cycle
Air compressor.....
.....Pennsylvania Pump & Comp. Co.
Soot blowers.....Bayer Co.
Feedwater regulators.....
.....Copes, Northern Equipment Co.
Injectors.....Penberthy Injector Co.
Piping.....National Tube Co.
Pipe covering..85 per cent mag—Carey Co.
Valves—
Gate.....Chapman Valve Mfg. Co.
Globe.....Chapman Valve Mfg. oC.
Non-return.....Illinois Engineering Co.
Safety and water relief.....
...Consolidated-Ashcroft-Hancock Co.
Blowoff.....Yarnall-Waring Co.
Steam and water.....
.....Chapman Valve Mfg. Co.
Pressure reducing.....
.....Boylston Steam Specialty Co.
Pressure gages.....
.....Consolidated-Ashcroft-Hancock Co.
CO_2 recorders and indicators.....
.....Uehling Instrument Co.
Temperature recorders.....
.....Taylor Instrument Cos.
Draft gages.....Ellison Draft Gage Co.
Venturi meters....Builders Iron Foundry
Steam flow meters.....Bailey Meter Co.
Subway grating.....Irving Iron Works
Water columns.....Wright-Austin with National Co. Illuminators
Steam traps.....Armstrong Machine Wks.
Transformers.....Wagner Elec. Co.
Electrical meters.....General Electric Co.
Switchboards, etc.....General Elec. Co.

Steam passes to the distribution system through a 14-in. lead, Fig. 1, running down to the pump room, which is in the southwest corner of the plant basement. From this point, a tunnel runs under the sidewalk on Mullett St.; by placing it under the sidewalk, construction could be carried on without tearing up the whole street or interfering with existing sewers, water lines and power lines. High-pressure steam is supplied to the receiving hospital for kitchen and laundry use and low-pressure steam is furnished for heating. All the other buildings use low-pressure steam for heating and making hot water.

No Feedwater Heater Provided

Condensate from the buildings is all returned to the boiler plant by a return line in the tunnel. Vacuum pumps at each building bring this condensate to the return line, which discharges to a receiver, Fig. 1, from which it is pumped to the boilers by 150-g.p.m., motor-driven centrifugal pumps. Amount of make-up water is so small that no feedwater heater was installed, the returns being hot enough to keep the final feedwater temperature at about 180 deg. Injectors on each boiler provide for boiler feeding in case of emergency.

All plant auxiliaries are driven by alternating current motors; these include stoker motors, which have a four-speed control. The latter are controlled from individual boards in front of each stoker, Fig. 2; on these boards are mounted also the draft gages and motor controllers for forced draft fans. Water columns are illuminated and are easily seen from the firing floor and water level is automatically controlled.

In the chief engineer's office are mounted two gage boards, one carrying five CO_2 recorders for the five boilers, the other carrying pressure indicating gages and recorders. Here also is mounted the recorder of a Venturi meter that measures total amount of water fed to the boilers. Flow meters record the output and distribution of the steam. Coal is measured by the weigh larry. With these instruments it is possible to keep a close check on the operation of the plant.

Mullett St. heating plant is constructed of steel and red face brick, with inside facing of cream brick. This facing, combined with the neat painting of the equipment and good illumination, give the plant interior a most attractive appearance. Despite the large amount of equipment in such a small space, the apparatus has been well arranged and there is no impression of crowding. On the contrary, the boiler room seems much larger than it really is.

Before the Institution of Civil Engineers, H. R. Ricardo recently pointed out that thermal efficiency in the internal combustion engine is greater for small bore than for large bore cylinders because of higher piston speed and compression ratio. Examples of 39.5 per cent on a racing aero engine and 38.8 per cent on an 8-in. Diesel at 1000 r.p.m. were cited and the range from 3 in. to 6 in. diam. given as best for high thermal efficiency. A. E. L. Chorlton reported an efficiency of 42 per cent for a small high-speed Diesel.

Chemist Tells Engineer about Turbine Oil

ENGINEER SHOULD SELECT PROPER OIL FOR PARTICULAR TURBINE AND SHOULD THEN GIVE ATTENTION TO OILING SYSTEM AT REGULAR INTERVALS. BY H. L. KAUFFMAN*

RECENTLY I RETURNED from a week's trip with a friend of mine, a sales engineer whose contacts are largely with power plants. I had nothing to sell; I was not even particularly interested in whether or not my friend sold anything; but I did want to find out the reaction of plant engineers to the quality of turbine oils now on the market. And what I learned was amazing!

All my life I have been engaged either in the refining of petroleum—that is, in the making of such products as turbine oils—or in aiding the proper utilization of them. And while I am not prejudiced either for or against turbine oils made by any particular manufacturer, it made my blood boil to hear what I knew to be good grades of oil cussed and criticized when, by following certain simple procedures, much better and more satisfactory results could have been obtained from any of the oils being used.

Conversation that follows does not represent my talk with any one individual—it's the gist of what was said in talking to a number of power plant operators.

"What's the best turbine oil to use?" was one of the questions most often asked me, when the inquirer was told that I was a petroleum chemist and lubricating engineer. The question meant, what's the manufacturer's name or the trade name of the oil I considered best.

"I can't answer that," I would reply. "Almost all oil companies make good grades of turbine oil."

CHARACTERISTICS OF GOOD TURBINE OIL

"Well then, what must a turbine oil be, to be good?"

"For best results in operation," I replied, "the turbine oil should be a highly-refined, pure mineral oil; it should separate readily from any water with which it may come in contact, that is, the oil should not form permanent emulsions with water; and it should be of such viscosity as to function most satisfactorily on the particular type of turbine being lubricated."

"Oh! I see!" came the reply, although the next question belied his words, "What do you mean 'highly-refined?' "

"Lubricating oil that has been so processed by the refiner that it contains a minimum quantity of easily-oxidizable compounds; of ingredients that make the oil emulsify more quickly; of anything that might make the oil form a sludge more readily; and naturally, one that is free from dirt and similar mechanical impurities. Refiners accomplish this high degree of purification necessary for turbine oils by filtering the oil through Fuller's earth after the oil has passed through a number of other refining stages. That's one reason why almost all turbine oils are light in color—the Fuller's earth decolorizes the oil while at the same time removing objectionable impurities."

"Um-m- huh-h! I know from experience why you have to have an oil that won't emulsify with water," commented the operator, having kept in mind my statement that a good grade of turbine oil should not readily emulsify. "About a year ago, an emulsified sludge used to form in our oiling system, bearing temperatures increased and we had to change the oil about every three or four weeks. The trouble came from our trying to use some so-called turbine oil purchased from a local oil jobber who substituted some motor oil on us—we found that out later." He paused for a moment and then asked, "Tell me, how in the deuce does water get into a turbine oiling system? And what is it that makes an oil emulsify?"

HOW WATER GETS INTO OIL-CIRCULATING SYSTEM

"Now," I replied, "you're getting on an interesting subject! If more engineers would strive to prevent the leakage of water into oil-circulating systems, there'd be less complaints on the quality of turbine oils. But I'm not answering your questions."

"Water can get into the oiling system in a number of ways. It may leak into the cooling coils or past the packing glands, in spite of the precautions taken by manufacturers in the construction of such glands. These glands are sometimes fitted with carbon packing rings held against the shaft by springs, by labyrinth packing or water seals, or by water throwers introduced between packing glands. By paying more careful attention to gland maintenance and to water seals when starting and stopping your turbine, you'll be better able to keep to a minimum the amount of water getting into the system."

"Then, too," I continued, "intermittently operated turbines generally show greater accumulations of water than continuously operated units. Further, moisture often gets into the oiling system when the turbine is at rest, due to condensation of water in the air. In turbines where the bearing shells are made hollow and cooled by circulating water, if there is any leakage in these coils, water may also enter the system from such leakage. For goodness sakes!" I emphasized, "don't blame the oil for emulsifying if you yourself haven't been taking all possible steps to prevent leakage of water into the oil from steam and water glands and cooling coils?"

WHY DOES OIL EMULSIFY WITH WATER?

"U-m-m huh-h-h!" came from my listener.

"Your question, 'What makes an oil emulsify with water?' is a little more difficult to answer. Generally speaking, it's because of the presence of some emulsifying agent either contained in the oil originally or formed therein while the oil was in use; or it's due to the presence of a similar agent in the water with which the oil comes in contact."

"You probably already understand," I continued, "that there are two types of emulsions: simple emul-

*Consulting Petroleum Chemist and Lubricating Engineer.

sions and permanent emulsions, although in the presence of heat and impurities, such as dust, dirt, fine metal particles, the former can change into the latter. Simple emulsions of oil and water in a turbine oiling system are not serious. That's because such emulsions don't cause stoppage of the oil passages nor result in failure of the lubricating oil film; however, simple emulsions do tend to hasten oil oxidation and thus indirectly are responsible for ultimate sludging of the oil. When a permanent emulsion is formed—one that does not break up readily into oil and water—some of the emulsion itself may settle out of the oil. But the larger portion usually will be kept in circulation, giving the oil a muddy appearance and acting as an agent to cause sludge formation. This sludge deposits on the cooling coils and insulates them. In severe cases, it causes a breaking of the oil film in the bearing, with an accompanying rise in bearing temperatures."

What Can Be Done to Prevent Trouble from Emulsions?

"Yes, I see—I see," interrupted the plant engineer. "But what precautions should I take, if emulsions form, to prevent them from causing trouble?"

"That's easy," I answered. "You're probably taking some of those precautions right now. Whether or not you're taking all of them, I don't know."

So I advised him, "To prevent emulsions from making trouble, remove them from the oiling system as rapidly as they form. That part of the emulsion which is carried with the oil in circulation is dangerous and can be removed only by drawing off a portion of the oil from the system for treatment. Sludge, water, emulsion and all other impurities that settle in the reservoir also should be removed.

"What I'm trying to tell you," I said, "is that you should practice a regular method of purifying the turbine oil. Otherwise, you won't get best results from the oil and damning the oil and the man who sold it to you won't help any. Personally, I favor an automatic system of purification either by filtration or centrifuging. Such a system can be employed either continuously or at regular intervals. Other methods, however, are often practiced; for example, a non-automatic method of draining off weekly about ten per cent of the oil in the system and purifying it. Whatever the means of purification used, be sure to keep the oil system up to capacity by the addition of new or purified oil. And naturally," I concluded, "I'm sure *you* aren't the kind of operator who doesn't clean strainers!" I thought a little flattery would do no harm.

Withdrawing Only Part of the Oil Avails Little

"Say, what's the objection to withdrawing just a part of the oil from the turbine base and replacing with new oil?" now asked the engineer in charge. "I can't see why that wouldn't be a good idea."

"Objection?" I repeated aloud, but to myself I said, "Are there still people so thick-headed?"

I tried to be patient in answering him.

"You wouldn't think of attempting to keep up the quality of the oil in the turbine base merely by adding enough new oil from time to time to keep the quantity up to the requirements of the machine, would you?" I asked.

"No," he answered. "I realize that such a practice would be dangerous and sooner or later would result in burned-out bearings and disabled machines, due to the accumulation of sludge and water."

"Then surely you realize," I said, "that if you withdraw from the system only a part of the oil from time to time, replacing the quantity withdrawn with new oil, you're improving only slightly over merely adding 'make-up' oil! In both cases, the impurities already present in the used oil are diluted, not removed. Furthermore, by such a method nothing is done to keep water, solids and oxidation products—with consequent acid-forming properties—from accumulating in the oil."

"That's right!" he commented emphatically, as if surprised at his own thoughtlessness. "But what's the matter with withdrawing the whole charge at intervals, purifying it and then returning the cleaned oil to the turbine oil reservoir. You could operate the turbine in the meantime either on new or purified oil."

"Well, let's just count the objections," I answered. "I think you'll agree with me on them, too. First, the turbine would have to be shut down while withdrawing the dirty oil and refilling the reservoir with clean oil. Second, by so doing you'd have no means provided for preventing an accumulation of water, emulsion, solids, sludge and other products of oxidation. Third—" I paused and asked a question. "The time for cleaning would be at your discretion, wouldn't it?"

"Yes."

"You might be right or wrong. Upon your judgment, or upon failure to clean on time, the oil might become absolutely dangerous and unfit for use in the turbine from a safety standpoint. Do you agree with me? Am I right or wrong?" I concluded.

Tests to Determine When Oil Should Be Changed

"I do and you're right!" came his answer to both my questions. "But tell me," he went on to ask, "what's the best way to find out whether a change in the oil is taking place? You know what I mean, a change that might ultimately result in the formation of dangerous quantities of sludge or emulsion?"

"That's a good question and I'm glad you asked it," I said and then continued, "The most convenient and successful way of determining the extent to which an oil is undergoing changes is to take weekly samples of definite size in glass bottles. A 4-oz. oil sample bottle is a convenient container to employ. A comparison of four consecutive samples of the oil in use should be maintained. All samples should be taken from the system at a point where the oil is thoroughly agitated. If taken from a point where the oil is quiet, sludge is apt to settle, in which case the sample taken would not be representative. Samples of the oil in circulation can be obtained either from the pressure oil line just before the cooler; or from the return oil line from the bearings; or from the oil reservoir above the level of the pump suction. Rubber stoppers or rubber packing rings should not be employed in bottles used for taking or keeping samples. Then——"

"Well, what do you do with the sample once you've taken it?" interrupted my listener.

"I'm coming to that," I replied. "Then when you've obtained a representative sample, date it and allow it to stand in a place where it won't be disturbed. Comparison of the weekly samples as to amounts of insoluble material that settle out upon standing will indicate any tendency toward a marked increase in the amount of impurities in the circulation system. This comparison should be made continuously. Individual entries in the record are of little value, since they form no basis for comparison from week to week. When the oil samples show a pronounced increase of insoluble material or sludge, steps should be taken immediately to purify the oil and to clean the system."

Determining State of Oil by Chemical Methods

Here a new thought struck me, so I asked, "You could get hold of one of the chemical students at the college to do a little work for you, couldn't you?" That particular day, I was visiting a power plant in a university town.

"Yes, I think so," was his reply. "But what could such a person do?"

"Well, where a chemist is available it's a good idea to have determinations made at regular intervals of what is known as the 'neutralization value' of the oil. To a chemist, this value indicates the number of milligrams of potassium hydroxide necessary to neutralize one gram of oil. The neutralization value increases slightly with the service of the oil in the circulation system. A sudden increase in the neutralization value is a fair index of the liability of oil to sludge or emulsify."

"And here's another hint," I added. "Sludge first deposits upon the cold surfaces of the cooling coils. So a careful check regularly on the condition of the cooler coils will also tell you when the oil is showing a tendency to form sludge."

"Thanks, I'll keep a closer look-out on the coils, especially," said the engineer appreciatively, and then went on to ask, "What do you think about keeping operating records, temperature records, for example?"

Full Records of Oil and Turbine Performances Are Necessary

"For getting best results from turbine oil I'm strongly in favor of rather detailed operating records, including data on operating temperatures. For temperature records, I'd suggest taking regularly the temperature both of the oil and of the water entering and leaving the cooler. A decrease in oil or water temperature differences indicates poor heat transfer due to insulation of coils with oil sludge or water scale. Be sure to take also the temperature of the oil from the bearings: a rise in temperature over normal indicates a deficiency in cooling of the oil, due usually to deposits in the cooler."

"Keep a log, too, on the oil or water-leaking tendencies of the turbine and of the means taken to correct the trouble; also, record data on the purification of the oil, as well as the date and quantity of added make-up oil."

"And here's another thing you ought to keep a careful record of," I went on, "and that's the date when the entire turbine system is cleaned, together with notes of interest concerning such cleaning or of any repairs or changes made at that time. The period for cleaning the turbine system will be determined and regulated by any marked increase in the amounts of deposits shown by comparing oil samples, or by an appreciable change in temperature records, or by a considerable increase in the rate of impurities deposited in the filters. In cleaning the system, first withdraw all oil from the turbine and purify it by any suitable means. Clean the bearing pedestals, the oil reservoir, the oil cooler and, if necessary, the oil pipes. After purification, either return the oil to service or pass it to oil-storage tanks. Then don't forget to clean the precipitation tanks and filters, or whatever equipment you've used to purify the oil. It's a good practice," I concluded, "where turbine service can be so adapted, to drain the system, clean it and to purify the oil regularly every thirty days."

"U-m-m-m huh-h-h!" came the familiar, meaningless grunt, and then, "When we first started talking, you said something about using a turbine oil of such viscosity as would give best results on the particular type of turbine being lubricated. What'd you mean by that?"

"Viscosity of an oil," I said, "is a relative measure of the resistance of the oil to flow. In other words, it's a measure of the internal or fluid friction of the oil. Here let me tell you that fluid friction is the friction created by the moving of one particle of oil over another. Now, the more viscous an oil is over that necessary to lubricate satisfactorily the rubbing surfaces—that is, the greater the fluid friction—the greater are the power losses. Further, when the improper grade of oil is being used, bearing temperatures increase, acids and gummy deposits form more rapidly in the oil and numerous other effects detrimental to efficient lubrication are to be noted.

"Well, here comes my friend now, I guess we'll have to be going. The next time I'm around this way, I'll be glad to tell you some more about this matter of viscosity in selecting a turbine oil."

"I wish you would," he replied.

Before I left, I handed the engineer a slip of paper on which I had written:

To Get Best Results from Turbine Oil

1. *Select a highly-refined, non-emulsifiable, pure mineral oil of the proper grade for use on the particular turbine being lubricated.*

2. *Pay close attention to the oil at regular intervals thereafter.*

But as I went out of the building, I was doubtful in my own mind as to whether or not he'd take my advice. But I was hoping for the best!

Establishment of the Holland Institute of Thermology, to conduct research into various phases of the relation of humidity, temperature and circulation of air to public welfare, has been announced by A. H. Landwehr, president of the Holland Furnace Co. of Holland, Mich.

Perhaps the greatest human happiness flows from personal achievement.—Herbert Hoover.

Pulverized Coal Burned at Calumet*

290,000 Lb. of Steam an Hour from Coal Having 18 Per Cent Ash and 14 Per Cent Moisture. By William H. Jensen†

CONSIDERING this method of firing, the Commonwealth Edison Co. has observed developments with somewhat conservative interest, looking at the economic problem as a whole rather than simply at thermal economy, which is only one part of the problem. When a point was reached where larger boiler installations were wanted than could be accommodated by stokers, it was decided to try burning pulverized central Illinois coal in an experimental installation, because of the special characteristics of the fuel and the need for elimination of dust from flue gases.

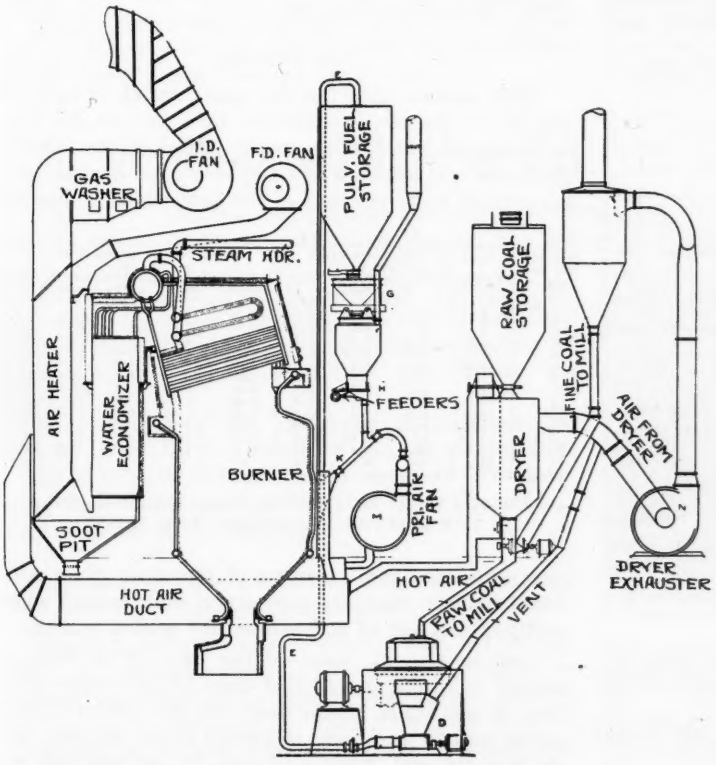


FIG. 1. BOILER AND AUXILIARIES FOR POWDERED COAL INSTALLATION AT CALUMET STATION

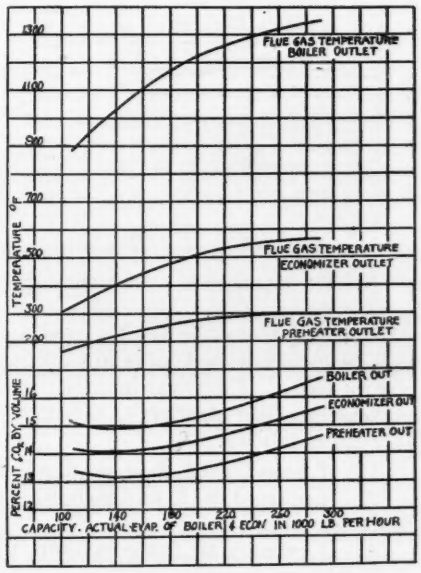

FLUE GAS TEMPERATURE BOILER OUTLET
FLUE GAS TEMPERATURE ECONOMIZER OUTLET
FLUE GAS TEMPERATURE PREHEATER OUTLET
TEMPERATURE °F
BOILER OUT
ECONOMIZER OUT
PREHEATER OUT
PERCENT CO2 BY VOLUME
CAPACITY - ACTUAL EVAP. OF BOILER & ECON IN 1000 LB PER HOUR

FIG. 2. FLUE GAS CONDITIONS AND EFFICIENCIES FOR OUTPUTS FROM 100,000 TO 290,000 LB. OF STEAM AN HOUR

Boiler No. 22 was, therefore, installed for bin and feeder operation and the report covers something over a year of operation.

Data of the Installation

Arrangement of the unit is as shown in Fig. 1, the Babcock & Wilcox boiler being 40 sections wide, 7 tubes high and 17 ft. long. The drum is 32 ft. 5 in. by 48 in., built for 375 lb. pressure.

Surface of the 3-pass superheater is 3000 sq. ft. or half that of the water heating surface. The economizer ratio is 1½. The air heater has 41,700 sq. ft. with 1960 2½-in. tubes. Induced draft is at 12 in. static pressure to handle 144,000 cu. ft. at 300 deg. F., with a 500-hp., 2-speed induction motor. Each of two forced-draft fans has 58,000 cu. ft. capacity at 70 deg. and 4 in., driven by a 100-hp. motor.

Raw coal passes through a Bradford breaker on its way to a bin, whence it drops through a valve to Fuller-Randolph dryer. Drying to reduce moisture from 14½ per cent to 10 per cent is effected by tempered, preheated air, supplied by two branches from the main air ducts and exhausted by fan N to two cyclones, P, which are vented to the atmosphere, fine dust dropping down the chute to the mill.

Coal Pulverization and Feeding

From the dryer coal goes to a drag feeder, into a chute, over a magnet and to the Fuller Lehigh, 70-in. mill of 15 t. an hour capacity. For the mill, which is driven at 125 r.p.m. by a 330-hp. motor, the grinding element consists of a ring in which four 15-in., 500-lb. steel balls roll, the sizing being determined by the screens used to 65 per cent through 200 mesh. Moisture is reduced 1 to 2 per cent in grinding.

Pulverized coal is discharged into a hopper above

*From a paper and discussion before the Western Society of Engineers.

†Boiler Room Engineer, Calumet Station, Commonwealth Edison Co.

the Fuller-Kinyon pump and is delivered by the pump to the boiler bins, through a 6-in. line E, indicators near the mill and on the main boiler control board showing the height of fuel in the fuel storage bin.

Gravity carries the coal from the bin through air-operated Bailey gates to the weighing hoppers G, thence to Bailey feeders H and into the stream of primary air from fan M. Four feeders each supply two Calumet burners, each feeder having maximum capacity of 10,000 lb. an hour and eight burners being used to a furnace.

Air Supply Control

Forced draft fans, located above the boiler, draw in air at room temperature and discharge through the preheater to two ducts, one on each side of the boiler. From these secondary air, dryer air and that needed to temper primary air are taken, the balance going to the boiler front.

Draft and pressure gages, flow water and temperature recorders, Bailey combustion control switch, hand

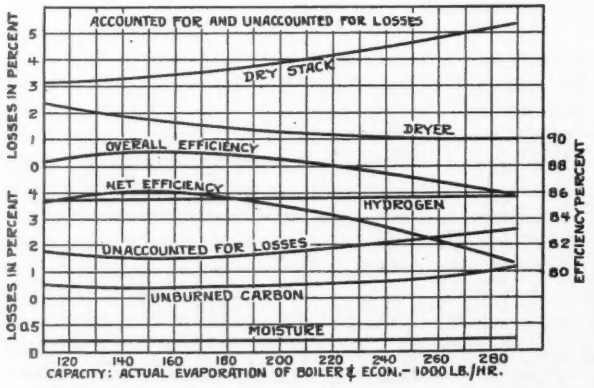


FIG. 3. VARIATION OF LOSSES WITH CAPACITY

wheel for control of feeder speeds by means of rheostats and feeder speed indicators are mounted on the boiler control board. Electrical interlock combinations which prevent incorrect starting or causing an explosive mixture are as follows:

1. If forced draft fans go down, feeder trips out.
2. If induced draft fans go down, feeder and forced draft trip out.
3. If primary air fan goes down, feeder and forced draft trip out.
4. Drag conveyor, Fuller-Kinyon pump and pulverizer are interlocked so that if the drag conveyor or mill stops, the other will stop; if the pump stops, the other two will stop; thus there is no chance to block the system with coal.

Operating Routine

From 7 a. m. to 10:30 p. m. the boiler is in daily operation, except Sundays. It is idle at night for operating reasons, since it is desirable to keep stoker-fired units on the line and banking the pulverized fuel unit is less expensive; also it can be more quickly brought into service in an emergency. After starting the fans, the unit will deliver 100,000 lb. of steam an hour in 10 min. and has been brought in on the line in 30 min. from cold. Pressure drop is 100 to 150 lb. during the idle period.

Boiler, economizer and preheater tubes rapidly become covered with fine ash but this is readily blown off with steam blowers operated for two revolutions once a day. Some slag collects on the lower row of tubes but is fairly easily removed by a hand air lance. For high capacity operation over extended periods, the slag would probably be more pronounced.

Combustion control is by a drum switch with five positions. In the first, second and third, feeding of fuel or air is independently controlled by push buttons. In the fourth position, induced and forced draft may be varied, forced draft being also automatically adjusted to furnace demands. In the fifth position, air and fuel may be varied together, both forced and induced draft being automatically adjusted to furnace conditions.

During most of the day, the boiler carries 150,000 lb. of steam an hour but may be called on for 50,000 to 75,000 lb. more for sudden demands and has delivered 290,000 lb. an hour for 4 hr.

Ash Disposal

Dust carried with the flue gases, which is some 60 per cent of the ash, is eliminated by a Carrier Air Conditioning Co. gas washer, located ahead of the induced draft fan. It requires 500 to 800 g.p.m. of water and removes 90 to 95 per cent of the dust which is dumped

Dry Coal Per hr., Tons	Power for Coal Preparation kw. hr. per ton				Power for Boiler Auxiliaries kw. hr. per ton				
	Dryers	Pulverizer	Fuller Kinyon	Total	Feeders & Conveyor	Primary Air	Forced Draft	Induced Draft	Total
5	3	9	0.75	12.75	0.75	-	-	-	-
6	4	11	0.9	15.9	0.75	2.75	9	23.5	36
7	4.9	12.6	1.0	18.5	0.65	2.60	8	20.5	31.75
8	5.5	14.25	1.25	21	0.6	2.5	6.5	18.0	27.6
9	6.25	16.25	1.4	23.9	0.55	2.35	5.5	16.2	24.60
10	7.0	17.5	1.5	26.0	0.5	2.0	8.0	24.0	34.5
11	7.6	19.5	1.6	28.7	0.5	1.75	7.8	23.8	33.85
12	8.0	21.5	2.0	31.5	0.45	1.55	7.8	24	33.80
13	8.5	23.0	2.0	33.5	0.45	1.25	8.0	25.5	35.20
14	9.5	24.8	2.0	36.3	0.45	1.25	8.25	27	36.95
15	10.25	25.5	2.25	39.0	0.45	1.25	8.5	29	38.70
16	11.0	28.0	2.3	41.3	0.4	1.10	9.0	31.2	41.70
17	11.5	30	2.4	43.9	-	-	-	-	-

KW-HR. USED PER TON OF DRY COAL FOR COAL PREPARATION, HANDLING AND DRAFT

into a railroad car. Cooling of the gases gives additional induced-draft fan capacity at high ratings which partly offsets cost of maintaining the washer system.

Ash in the pit, some 40 per cent of the total, is usually as pieces of slag that drop off the water-cooled floor or side walls. Some dust, caught under the economizer and air preheater, is flushed to the ash car. For the Kincaid coal, which has some 18 per cent ash and 14 per cent moisture, the slag melts and runs into the pit, while slag from Perry Co., Ky., coal collected on the rear wall and had to be broken off by hand.

Maintenance of Equipment

As little brickwork is exposed to furnace heat, maintenance has been small. The Bailey walls have required replacement of only 30 blocks and this because of direct blast of the flame from the end burner which was 2 ft. from the wall. It was later found that 3 ft. should be the minimum distance.

In the ball mills, after 350 to 400 hr. of service, the balls become egg-shaped and slide instead of rolling. This is some 1000 t. of coal ground per ball for the Kincaid coal as against 3000 t. for Kentucky coal, due to the character of the ash content.

Operating results are shown in Fig. 2 and in the table as obtained with Perry Co., Ky., coal.

During 6 mo. of 1927, coal of 11,828 B.t.u. per lb. was used and actual operating evaporation was 8.26 lb. steam per pound of coal. Overall efficiency, including dryer, dust and other operation losses, was 86.5 per cent, or within 2.5 per cent of the possible maximum as shown on the curves.

Gas temperature at the stack is reduced to 250 deg. F.

Kilowatt-hour consumption per ton of coal to run auxiliaries was 62, which reduces net efficiency a little over 4 points.

On the average, the unit has produced 140,000 lb. of steam an hour for 15 to 16 hr. a day, the maximum being 295,000 lb. an hour for a space occupied by boiler and auxiliaries of 1½ times that for a stoker-fired unit whose maximum capacity is 145,000 lb. an hour.

Ash pit loss is only ½ of one per cent while excess air is reduced to 20 per cent and flue gas temperature to 250 deg. F., thus lowering stack losses.

It is estimated that for low load some 35 per cent and for high load 25 per cent of heat absorption takes place in the water walls.

Percentage of CO_2 drops as gases pass through economizer and preheater, due to air infiltration. This drop would be reduced by absolutely tight settings.

Lowering of flue gas temperature, as shown by the curves, indicates the recovery of heat in economizer and preheater. Net efficiency is the overall efficiency corrected for power used by auxiliaries. The losses from various causes are shown in Fig. 1 and increase with output except for the dryer which decreases as a percentage.

Power used is tabulated for both coal preparation and draft. There is a sudden jump beyond the use of 9 t. of dry coal an hour in boiler auxiliary power, due to requirements for forced and induced draft fans.

In the discussion, Messrs. A. D. Bailey, A. E. Grunert and W. H. Jensen gave information, in response to questions, which has been embodied with the data presented in the paper.

Traveling with the Editor Through Michigan

HIGH-SPEED TURBINE DRIVING TWO GENERATORS, INTERESTING BOILER INSTALLATIONS, LARGE CORLISS ENGINE, ARE AMONG FEATURES OF RECENT DEVELOPMENTS

DURING A RECENT trip through Michigan, the editor encountered a wide variety of power plant practice in industrial plants. Outstanding points of interest, as observed in several of these plants, are given below.

Watervliet Paper Co., at Watervliet, Michigan, has recently remodeled its boiler room and has also installed a new turbine-driven generating unit, all this work being done under the supervision of C. J. Chamberlin, chief engineer of the company.

TURBINE DRIVES TWO GENERATORS THROUGH REDUCTION GEAR AT WATERVLIET

Figure 1 shows the new generating unit, a 1500-kw., 250-v., d.c. generator driven at 514 r.p.m. through a reduction gear; the turbine runs at 5000 r.p.m. Most of the paper mill machinery is driven by various types of d.c. motors, which form most of the load. Up the river, however, about half a mile, the company has a pumping station that serves the mill with water. This contains four 1000-g.p.m. vertical-shaft centrifugal pumps, with a suction lift of 30 ft. and a pumping head of 110 ft. These pumps are driven by 60-hp. vertical squirrel-cage motors. A fifth unit is being installed now. To avoid replacing these motors, a 187.5-kv.a. alternator was put on the shaft of the generating unit, primarily to serve these pumps.

Formerly the alternating current for the pumps, as well as for one or two mill pumps and a Jordan drive motor, was supplied by the Public Service Company but the company is now taking it over and buying the transmission line to the pumping station.

While the turbine is designed for 250-lb. throttle pressure, it is operated usually at about 200 lb. with 175 deg. of superheat. It operates straight-condensing

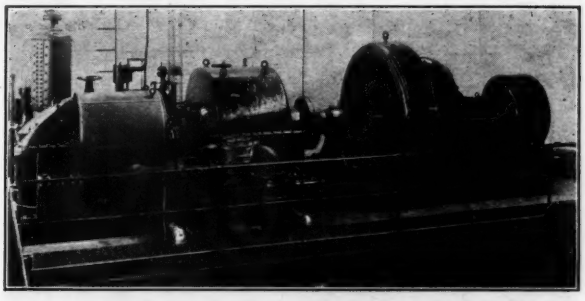


FIG. 1. NEW TURBINE AT WATERVLIET PAPER CO. DRIVES D.C. AND A.C. GENERATORS ON SAME SHAFT

or as a bleeder. It is designed to bleed 6000 lb. an hour at 8 lb. gage for process and heating and a 2650-sq. ft. surface condenser is installed, capable of handling the full load exhaust when under straight condensing operation.

ROTORS OF ALTERNATOR AND MOTOR-GENERATOR ARE OVERHUNG

Rotor of the alternator is overhung on the main shaft, outboard of the main d.c. generator bearing. This construction is also used on a remodeled motor-generator set installed on the main floor. A 200-kw. d.c. generator was belt-driven by a steam engine. The driven pulley which was overhung, was removed, the rotor of a synchronous motor put in its place, the stator fitted over it and the unit operates with entire satisfaction. This motor-generator set can be reversed to supply alternating current in case the main unit is shut down, driving it from one of the engine-driven d.c. units. Its most common use, however, is with the synchronous motor driving to secure power factor correction.

FIG. 2. ONE OF THE NEW 3-DRUM BOILERS AT WATERVLIET UNDER ERECTION, REPLACING THE OLD VERTICAL UNITS

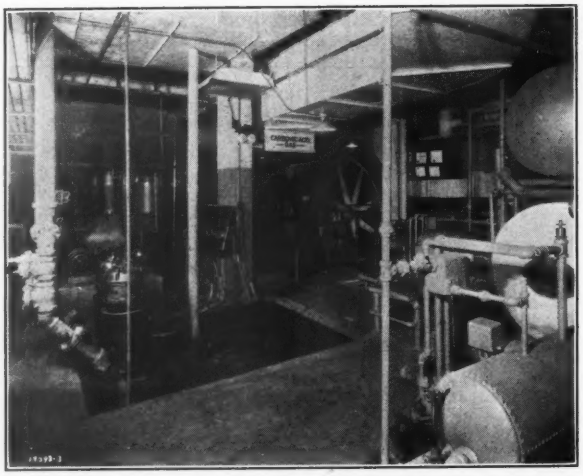


FIG. 3. GENERAL VIEW OF MACHINE ROOM AT DETROIT-LELAND HOTEL

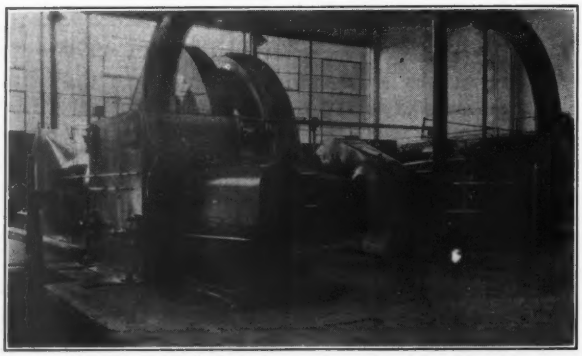


FIG. 5. TWIN CORLISS ENGINE AT CONSOLIDATED PAPER CO. DRIVES 2500-KV.A. GENERATOR AND SUPPLIES EXHAUST STEAM TO DRYERS

In the boiler room, four new 3-drum boilers of a type recently placed on the market, were installed, as shown in Fig. 2, to replace old vertical water tube boilers. The new units, fired by underfeed stokers, are of 610 b.hp. capacity each, making steam at 200-lb. pressure, 175 deg. superheat at 175 per cent of rating, although they are designed for 250-lb. pressure. Boilers and settings are designed for 250 per cent of rating; they have been operated continuously at 200 per cent, but with the average load, the rating will probably not exceed 150 per cent.

Detroit-Leland Hotel Buys Heating Steam and Makes Laundry Steam

At the Detroit-Leland Hotel, Detroit, Mich., a rather unusual layout was found, in charge of Joseph Watson, chief engineer. All steam for heating is purchased from

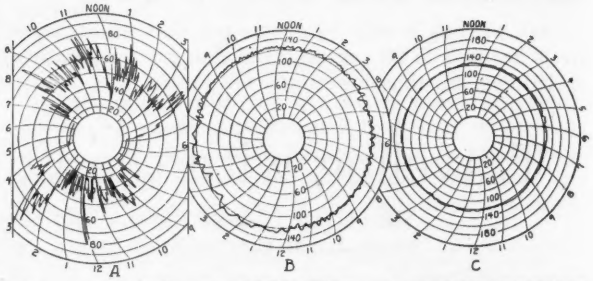


FIG 4. RECORDS OF OPERATION AT TIMKEN-DETROIT BOILER PLANT. A—TYPICAL STEAM FLOW CHART. B—STEAM PRESSURE BEFORE COMBUSTION CONTROL WAS INSTALLED. C—STEAM PRESSURE AFTER COMBUSTION CONTROL WAS INSTALLED

a local district heating system at 20 to 30 lb. gage pressure. The hotel operates a laundry, however, which requires steam at 100-lb. pressure. To furnish the latter, two 30-hp. vertical boilers were installed, fired by oil burners.

All power is purchased, coming in at 4600 v. through two 200-kv.a. banks of transformers that step it down to 220 and 110 v. Two feeders from different substations of the power company run to the hotel and an automatic throw-over device is installed to connect the transformers to either feeder, thus insuring continuity of service.

In the machine room, Fig. 3, are installed two large CO_2 compressors and one smaller one, to furnish refrigeration for the dehumidifiers of the air conditioning systems, which are in 24 units, handling a total of 315,000 c.f.m. of air. They also supply the ice tanks and other services. Refrigeration for kitchens and other smaller services is supplied by individual machines at various points in the hotel. As shown in Fig. 3, vacuum machines for the cleaning system, sump pumps and other equipment are installed; vacuum pumps serve the heating system which contains about 34,000 sq. ft. of radiation.

Timken-Detroit Axle Co. has recently installed two 3-drum boilers of the same type and make as those at Watervliet, fired by the same make of underfeed stokers. Each boiler is rated at 671 hp. but is usually operated at about 200 per cent of rating. Settings, boilers and stokers are designed for 250 per cent of rating continuously and for 300 per cent peaks. Steam

pressure is 125-lb. gage and tests have shown that, because of certain construction features of the boilers, 35—40 deg. of superheat are obtained without superheaters. An unusually complete instrument and control board was installed, carrying flow meters, CO_2 and temperature recorders and other necessary instruments.

Most of the steam generated by this boiler plant goes to a hammer shop, thus producing an extremely fluctuating load. Figure 4-A, a typical steam flow chart, shows a common load condition. It was extremely difficult, with such extreme fluctuations, to keep steam pressure constant with hand control as shown in Fig. 4-B. Accordingly, a combustion control system was installed and the chart of steam pressure now appears as in Fig.

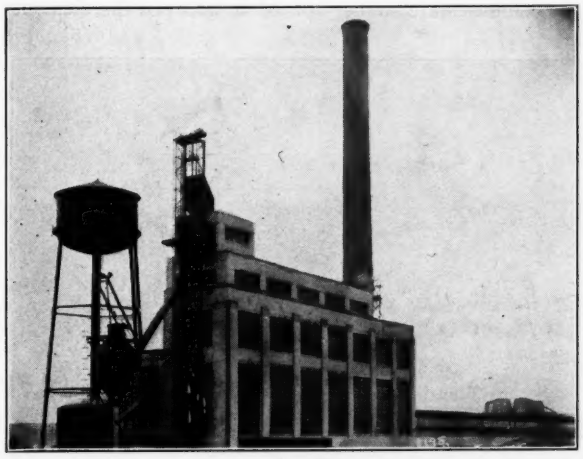


FIG. 6. BOILER PLANT OF YELLOW TRUCK & COACH MFG. CO.

4-C. This is considered extremely satisfactory. This plant is in direct charge of John Hogan, chief engineer, while H. W. Strauss, plant engineer of the company, is in charge of all power development and supervised installation and operation of the new equipment. The plant also contains a 1500-kw. turbine-generator and some other older boilers about which little can be said at this time.

Consolidated Paper Co. Installs Large Corliss Engine

One of the largest Corliss engines ever installed was found at the plant of Consolidated Paper Co., Monroe, Mich. This engine, Fig. 5, put in operation about a year ago, is a twin unit, with 34-in. by 48-in. cylinders, driving an alternator of 2500-kw. capacity, 1.0 p.f. It is designed so that either cylinder can carry about three-quarters of the load. Throttle pressure is 150-lb. gage and the engine exhausts at 25-lb. to the paper mill dryers.

Yellow Truck & Coach Co. Burn Coal and Wood Waste

Exterior of the new boiler plant of Yellow Truck & Coach Mfg. Co., Pontiac, Mich., is shown in Fig. 6. This plant was designed by the engineering department of Fisher Body Corp., which designed the plant at Flint described in the February 1, 1928 issue of Power Plant Engineering. Except for the sizes of the units and the arrangement, much of the equipment is of the same type and make as at Flint. W. C. Lilley is chief engineer.

Steam is generated by four 3-drum boilers set in a row, with space for two others at the end. If it is desired later, the plant can be extended for a similar row of boilers opposite, with the space in front of the present boilers as the firing aisle. Coal handling equipment, consisting of storage yard, drag scraper, skip hoist, bunkers and weigh larry, has been laid out with this expansion in view.

Boilers are of 722-hp. capacity each; three of them are fired with coal by underfeed stokers. The fourth unit has a furnace designed to burn wood waste, delivered by a wood stoker overhead, or pulverized coal, delivered through a turbulent burner by a unit pulverizer in the basement. Each boiler carries an indicator for CO_2 and CO, a flue gas pyrometer, flow meter and pressure gage.

All power is purchased, the plant supplying only steam and compressed air to the factory. In the compressor room, two angle-compound compressors are installed, each 22 and 13 by 14 in., driven at 257 r.p.m. by 17 by 16-in. piston-valve steam engines.

Emulsion Avoidance

Causes of emulsion are the presence of water and dirt in the lubricating oil system and the action is accelerated by sudden cooling of the oil.

To avoid emulsion: first, use an oil that has least tendency to form an emulsion with the water used in the plant; second, prevent, by every possible means water from getting into the system; third, arrange the bottoms of oil reservoirs to prevent low spots that act as traps for water, sludge or dirt but have a definite point for settling out of impurities—in large systems an independent filter is desirable with sight glass—and examine this point regularly for accumulations of impurities, removing them as often as necessary to prevent their being carried into the stream of lubricating oil. Use a large drain pipe to permit easy flow of even semi-fluids.

Emulsification of the oil with water should be checked occasionally, as it will vary with the character of the water, often from winter to spring or summer.

Advance of arc welding in structural work was emphasized at the meeting of the recent American Welding Society in Cleveland. Examples of the use of this method in field and shop fabrication were given by Joseph Matte, Jr., of Albert Kahn, Inc., architects and engineers, and a promising future was predicted with less noise and lower costs.

Need of building codes to include this new method and of standard specifications for welded structural work was voiced by William D. Guion, Cleveland, commissioner of buildings, and by Charles W. Schubert, engineer in the Cleveland inspection department. J. F. Lincoln, vice-president of Lincoln Electric Co., called attention to improvements in welding processes which promise to reduce welding costs 75 per cent so that the former excess of cost of welding over riveting is likely to be reversed.

Economizers and Superheaters Help Small Boilers

IMPORTANCE OF FUEL SAVING IN SMALL PLANTS RECOGNIZED IN INTERESTING H. R. T. BOILER INSTALLATION AT THE FIRTH CARPET CO. PLANT

SUPERHEATERS ARE often applied in horizontal return tubular boilers but it is an exception, rather than a rule, when these units are equipped with steel tube economizers. Yet fuel in a small plant is as important as in a large central station and the percentage of fuel that can be saved by a well-designed economizer is an item of importance in either type of plant.

At the plant of the Firth Carpet Co., Firthcliff, N. Y., shown in Fig. 1, an excellent example of small boiler plant design has recently been put into service, incorporating both these features.

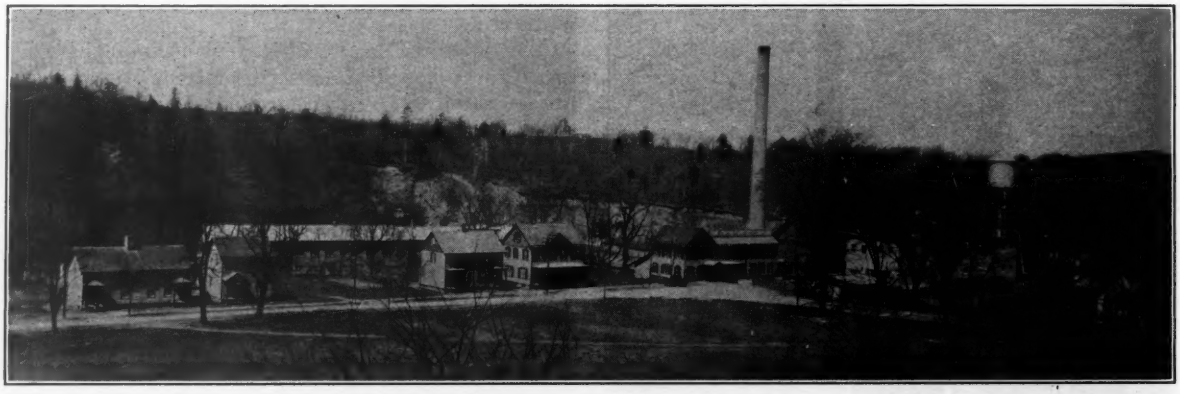


FIG. 1. GENERAL VIEW OF THE FIRTH CARPET CO. FACTORY

TWO H.R.T. BOILERS, WITH HIGH SETTINGS ARE DESIGNED FOR 150 PER CENT RATING

This plant, of which Andrew Kidd, Jr., was consulting engineer, has installed two new 78-in. by 20-ft. h.r.t. boilers each containing 112 3½-in. tubes. They were built for 150 lb. pressure and have been set 10 ft. above the floor line. They are rated at 220 hp. each and the Detroit underfeed stoker, with an area of approximately 60 sq. ft. of grate surface, was designed to develop at least 150 per cent of rating. Stokers are complete with fans and are driven by an Engberg vertical steam engine, the speed of which is controlled by the steam pressure.

Although the first installation consists of but two boilers, one side of the boiler house is a temporary end so that additions can be made.

Breechings, steam headers and other parts of the plant have been designed for an ultimate capacity of 2000 b.hp. The old boiler plant is equipped with an induced draft fan and the breeching for the new boiler house is connected to the second part of this plant, which discharges to a chimney 175 ft. high, 8 ft. in diameter at the top.

Steam generated in the new boiler is to be used for the turbine, while the steam generated in the old boiler house is to be used exclusively for process work.

Both economizers and superheaters are used, the arrangement and design being shown in cross section, Fig. 2. The superheaters are installed in the rear combustion chamber and are designed to give 100 deg. superheat when the boilers are operating at 150 per cent of rating. New superheater elements, which are also shown in Fig. 3, are protected from the radiant heat by the brickwork directly in front of them. They are open only at the side and the gases coming back from the combustion chamber spread in between the elements and supply the heat necessary for superheating of steam. They can be drained through the return headers at the bottom and may be flushed out by the operating engineer at will.

Drain pipes are carried through the rear wall and parts of these are lightly tacked to the installation to permit the movement of the pipe and to prevent air infiltration. The elements are located at the side of the setting so that it is possible to expand the boiler tubes without moving the superheaters. Figure 3 was taken before the protective brickwork was installed for the blowoff line shown in the foreground.

ONE ECONOMIZER SERVES TWO BOILERS

One 1440-sq. ft. economizer is used for the two boilers and is placed directly over the uptake and directly under the breeching. The economizer is operated under full boiler pressure and is guaranteed to raise the temperature of the feedwater from 200 to 294 deg. F. when the boilers are operating at 150 per cent of rating and to lower the flue gas temperature from 650 to 440 deg. F. with a draft loss of 0.35 in.

The economizer is built on the usual Foster countercurrent principle; the gases pass in one direction and the water in the opposite. In this case, the gases pass up through the economizer and the water downward through it. Such an arrangement would have been considered impossible a few years ago but can be handled satisfactorily in this special design using a relatively small number of tubes to carry the water, thus increas-

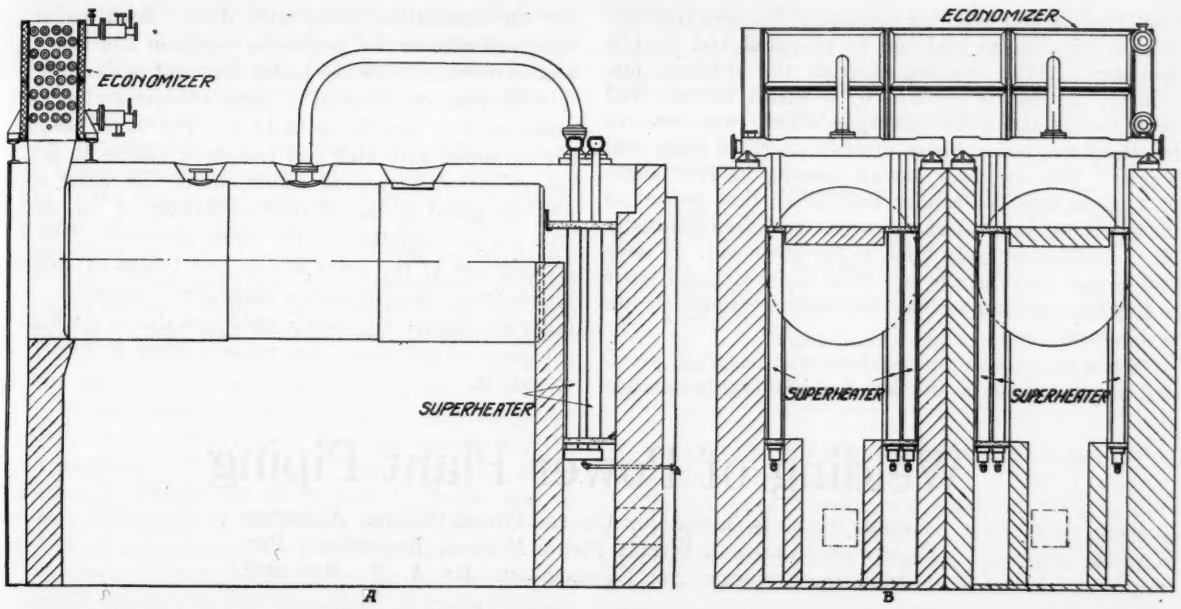


FIG. 2. SIDE AND END ELEVATION OF THE BOILERS, SHOWING THE ARRANGEMENT AND DESIGN OF THE ECONOMIZERS AND SUPERHEATERS

ing the velocity to a point where the possibility of unsatisfactory operation due the formation of steam pockets and water hammer is eliminated.

Advantages of the Economizer with H.R.T. Boilers

Although the percentage of fuel saving effected by the economizer is the only economy that can be definitely guaranteed in dollars and cents, it is by no means the only advantage to the company from the installation of an economizer. This is particularly true in the case of return tubular boilers, where foreign matter naturally can collect at the bottom of the boiler during shut-down periods and cake there when getting up steam.

Consequently the boiler sheets frequently sag and blister. Installation of an economizer provides that foreign material will be thrown out in suspension. The temperature in the economizer is not sufficiently high to form a large scale and the foreign matter is easily cleaned from the economizer, whereas the same material when heated to high temperature in the boiler would scale badly.

Another advantage of the economizer is the increased capacity which it gives the boiler unit. This means that for the same amount of steam the boiler can be run at a lower furnace rating with a corresponding reduction in maintenance and repairs. To some operators, these claims may seem to be relatively insignificant but they are now so thoroughly proved that they are accepted by the majority as unquestionable.

Coal and Ash Handling Equipment

Because of the high boiler setting, practically any high-volatile, low-grade, slack coal can be burned but

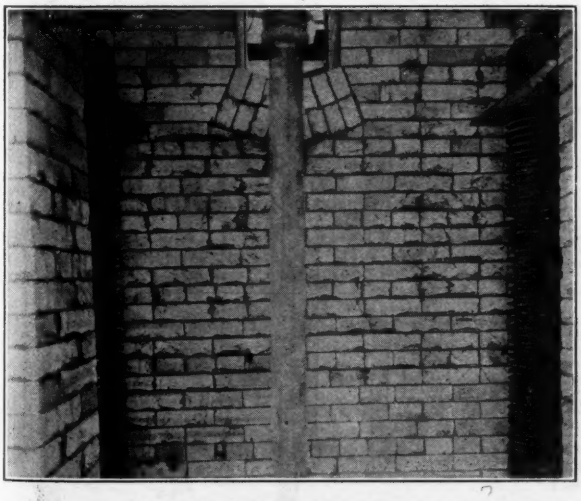


FIG. 3. SUPERHEATER ELEMENTS ARE SCREENED FROM THE RADIANT HEAT BY THE BOILER SETTING

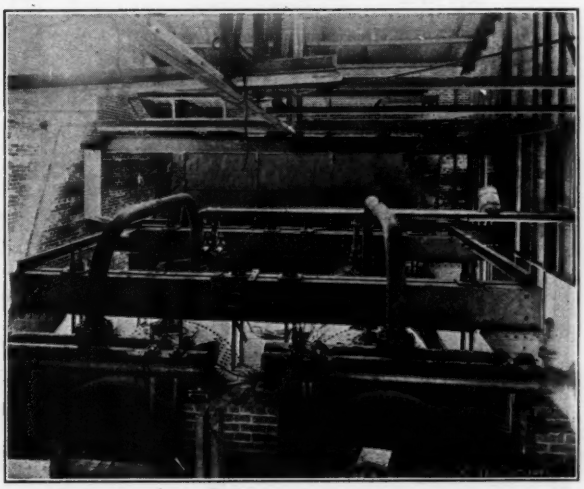


FIG. 4. ONE ECONOMIZER SET ABOVE THE BOILERS SERVES THE TWO UNITS

coal crushing and handling equipment has been installed so that run-of-mine coal can be prepared and used if necessary. After passing through the crushing machinery, the coal is elevated by a bucket elevator and deposited in the screw conveyor which runs the full length of the boiler house directly over the large coal hopper. This conveyor has an opening its full length of 4 in. so that the hopper will fill up first nearest to the receiving point of the conveyor and then gradually fill up until completely filled to the other end. If slack coal is used, there is a bypass from the receiving hopper to the slack elevator so that the crushing equipment can be bypassed.

While no ash handling equipment is installed, provision has been made in the floor and building foundation for an installation at a later date. Each boiler is equipped with an S-C feedwater regulator and Diamond soot blowers for both the boiler flues and economizer.

This plant as designed is highly efficient and as automatic as it is possible to build it. The water columns are equipped with high and low water alarms to notify the operator of unusual conditions of the water level and the speed of the driving mechanism of the stoker and fan is controlled by the steam pressure. The increased cost of the plant due to installation of stokers, economizers, superheaters, feedwater regulators and other equipment will soon be paid back due to the higher efficiency of the plant and reduced labor necessary to operate it.

Welding of Power Plant Piping

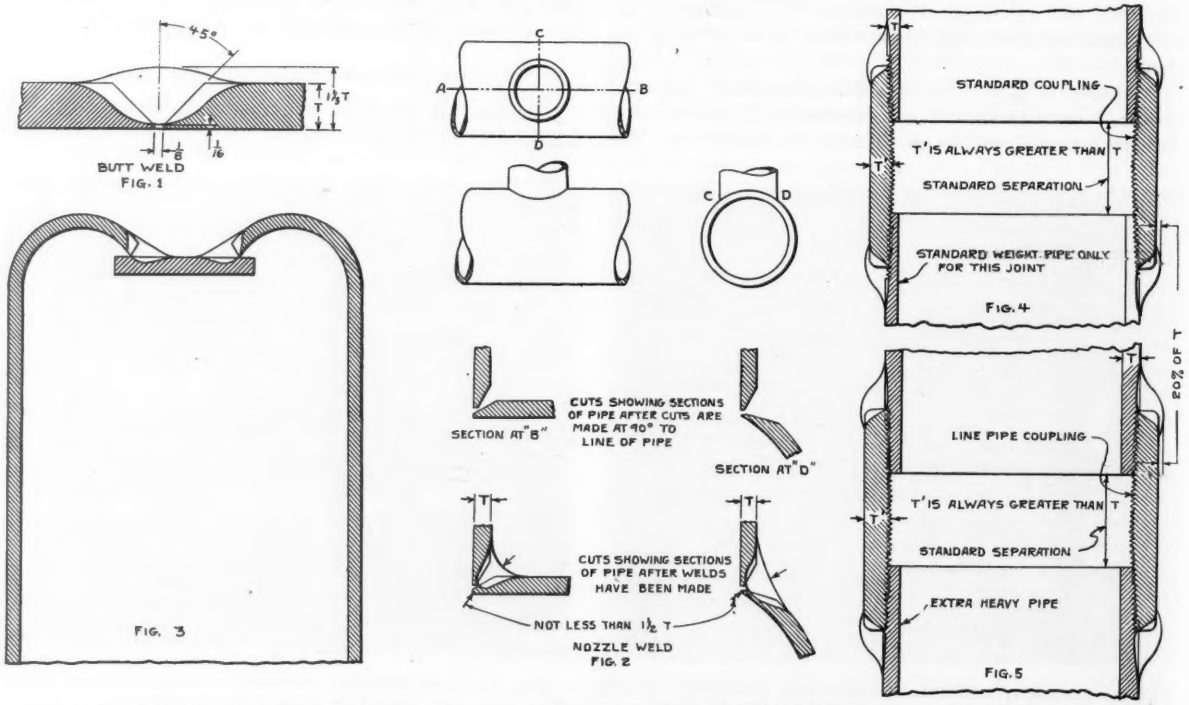
WELDED PIPING IS GROWING IN USE FOR POWER PLANTS. ACCIDENTS CAUSED BY FAILURE IN WELDED PIPING MADE BY RESPONSIBLE PIPE FABRICATING CONCERNS ARE UNHEARD OF. BY A. W. MOULDER*

WELDING OF POWER PLANT PIPING is unquestionably growing in favor steadily. There are a number of basic reasons behind this growth, such as the elimination of screwed and flanged joints with resulting lower maintenance cost, lower first cost, especially where a multiplicity of connections are to be made to a pipe in a limited area such as in the case of headers, decreased weights, as where welded steel is substituted for large cast fittings and in overcoming the time required for the making up of special or odd shaped fittings. Continuity of insulation is permitted by eliminating flanges. This results in increased efficiency and decreased cost of insulation and improved service in erection, especially where field welding is employed.

All of the above advantages were, of course, recognized in the early days of pipe welding. The importance of power plant piping, however, is such that a failure not only endangers the life and limb of employes, but cuts off a most important service, and this has had a just deterring effect upon the growth of welding for this type of work as compared to its growth in other classes of piping work.

Today it is not unusual to be called upon to fabricate

*Manager Heating, Power and Industrial Piping Division, Grinnell Co. Abstract of paper presented at joint meeting of Metropolitan Section of A. S. M. E. and the American Welding Society.



DETAILS OF VARIOUS WELDS. FIG. 1. BUTT WELD. FIG. 2. DETAILS OF NOZZLE WELD. FIG. 3. END WELD. FIGS. 4 AND 5. LINE WELD

welded piping for 400 lb. superheated steam and total temperatures up to 750 deg. F. The writer has yet to learn of any accident ever having been caused by a failure in welded piping made by any responsible pipe fabricating concern.

On the opposite side, the question naturally arises, why hasn't welding of power plant piping grown to a point of the almost exclusive use to which its many advantages would seem to indicate it is entitled? The answer today is just the same as it was ten or fifteen years ago. What assurance has the purchaser that the welds are properly made? The answer to this has been made many times, and resolves itself largely into one word: management. As applicable to the welding of piping, this includes or is composed of several parts:

1. Proper materials, basically as to their inherent qualities and artificially as to their preparation for the work involved, 2. Proper tools, 3. Proper methods of instruction, 4. Proper test of welders, 5. Proper test to see that the failure of the human element does not destroy all of the values of the preceding factors.

The basis of most welds, either for butt welding of two parts together or for the making of special fittings is shown in Fig. 1. The preparation is the same as the generally accepted standard excepting that the spacing between the bottom edges has been increased from $\frac{1}{16}$ in. to $\frac{1}{8}$ in. Inspection of sections cut from welds have shown a tendency for these bottom edges to overlap after the welds had cooled and contracted. The wider spacing has shown a better condition on the inside of the pipe.

Figure 2 covers the preparation for a nozzle weld. This style of preparation and welding has become a generally accepted standard. Figure 3 shows a weld at the end of the pipe when the weld is made in the shop. This type of joint provides extreme safety in that the plate is entirely inside of a rolled joint. Attention is called to the shape of the fillets. The fillets should in all cases

RESULTS OF TESTS ON OXWELD JOINTS MADE ON ONE SIZE PIPE WITH DIFFERENT TYPES OF JOINTS

Pieces Tested	Type of Joints	Pos.	Broke Off in Welds Loads in Tons	Pos.	Broke Off in Pipe Loads in Tons
		Pipe 4 in.O.D.- 0.1875 in.thick			
6	Normal Sockets	-	-	6	67.000
6	Socket & Pins	-	-	6	67.833
6	Butted Joints	-	-	6	69.000
		Pipe 8 in.O.D.- 0.1860 in.thick			
6	Normal Sockets	-	-	6	140.160
6	Socket & Pins	-	-	6	140.160
6	Butted Joints	1	147.000	5	131.800
		Pipe 12 in.O.D.-0.2500 in. thick			
6	Normal Sockets	1	288.00	5	270.400
6	Socket & Pins	1	262.00	5	252.000
6	Butted Joints	1	280.00	5	283.400
		Pipe 16 in.O.D.-0.3125 in. thick			
6	Normal Sockets	4	426.50	2	420.000
6	Socket & Pins	6	377.83	-	-
6	Butted Joints	5	421.20	1	446.000

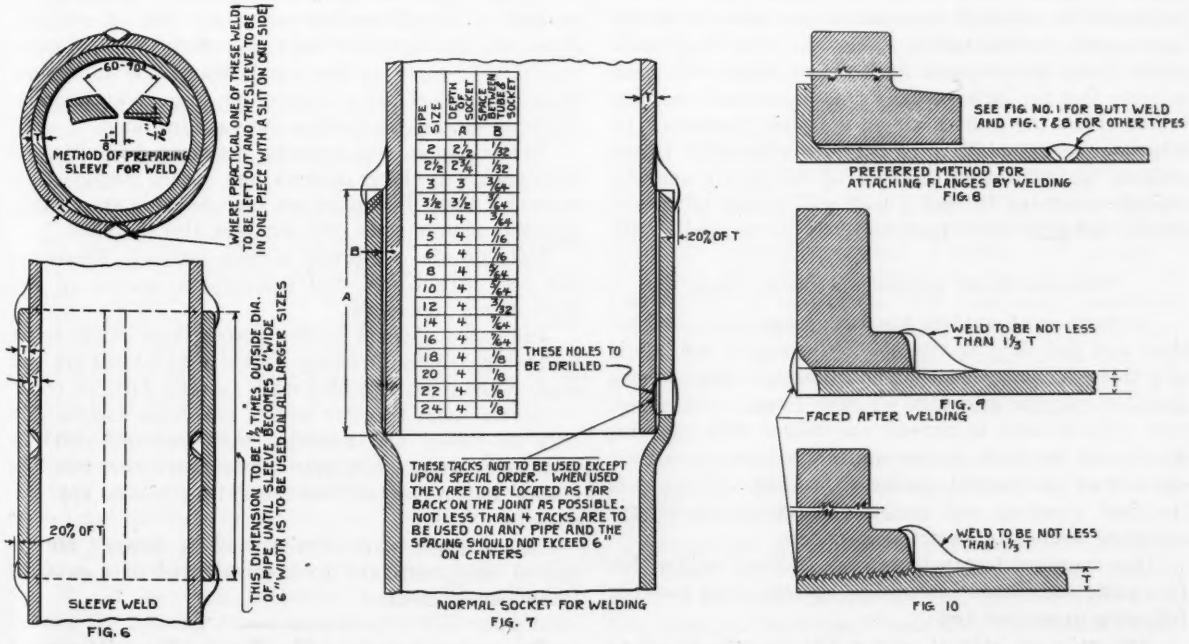
be so made as to provide a thickness of fillet material in excess of the pipe materials.

Various types of welds in common use for long lines of piping are shown in Figs. 4, 5, 6 and 7. Particular attention is called to Fig. 7, which illustrates two types of welds which, in later tests are mentioned as normal sockets as illustrated on the left side of the figure, and normal sockets with pins, illustrated on the right half of the figure.

In Figs. 8, 9 and 10 various types of flange welds are illustrated. The use of flanges as in Fig. 8 is preferable for field welding, because the long skirt prevents any warping of the flange sufficient to make refacing necessary.

Tests Show Welds as Strong as Pipe Itself

Summaries of 72 tests made on three types of welds for pipe ranging from 4 to 16 in. are given in the table. It will be noted that even those pieces which broke in the welds themselves held an average tensile load practically equal and in many cases in excess of the pieces


60-70°
METHOD OF PREPARING SLEEVE FOR WELD
WHERE PRACTICAL ONE OF THESE WELDS TO BE LEFT OUT AND THE SLEEVE TO BE IN ONE PIECE WITH A SLIT ON ONE SIDE
20% OF T
THIS DIMENSION TO BE 1½ TIMES OUTSIDE DIA. OF PIPE UNTIL SLEEVE BECOMES 6" WIDE 6" WIDTH IS TO BE USED ON ALL LARGER SIZES
SLEEVE WELD
FIG. 6
PIPE SIZE
DEPTH OF SOCKET A
SPACE BETWEEN TUBE & SOCKET B
2 2½ 1/32
2½ 2¾ 1/32
3 3 3/64
3½ 3½ 1/16
4 4 3/64
5 4 1/16
6 4 1/16
8 4 3/64
10 4 3/64
12 4 3/32
14 4 1/64
16 4 1/64
18 4 1/8
20 4 1/8
22 4 1/8
24 4 1/8
THESE HOLES TO BE DRILLED
20% OF T
THESE TACKS NOT TO BE USED EXCEPT UPON SPECIAL ORDER. WHEN USED THEY ARE TO BE LOCATED AS FAR BACK ON THE JOINT AS POSSIBLE. NOT LESS THAN 4 TACKS ARE TO BE USED ON ANY PIPE AND THE SPACING SHOULD NOT EXCEED 6" ON CENTERS
NORMAL SOCKET FOR WELDING
FIG. 7
SEE FIG. NO. 1 FOR BUTT WELD AND FIG. 7 & 8 FOR OTHER TYPES
PREFERRED METHOD FOR ATTACHING FLANGES BY WELDING
FIG. 8
WELD TO BE NOT LESS THAN 1⅓ T
FIG. 9
FACED AFTER WELDING
WELD TO BE NOT LESS THAN 1⅓ T
FIG. 10

METHODS OF WELDING IN COMMON USE—FIG. 6. SLEEVE WELD. FIG. 7. LEFT HAND, NORMAL SOCKET WELD, RIGHT HAND, NORMAL SOCKET WELD WITH PIN. FIGS. 8, 9 AND 10. VARIOUS TYPES OF FLANGE WELDS

which broke entirely outside of the weld zone. It might be added that no pieces in the entire test broke at a point which indicated low strength.

Our required test for welded high-pressure steam piping is as follows: "Welded piping material will be subjected to a hydrostatic pressure of three times the maximum allowable working pressure. Welds shall be hammered while under test, the hammering to be done all around the weld on both sides with a hammer weighing from 2 to 6 lb., depending upon the size of the pipe, and the blows shall be as heavy as possible without deforming or injuring the material."

Conclusions reached from recent research work would indicate that welded joints made to proper design are just as safe proportionately when used in connection with high pressures and temperatures encountered in the modern power plants as they have been found to be by years of trial and experience operating under the lower pressures.

Engineers responsible for the piping going into modern power plants realize that they are dealing with a problem where a single failure may be of tremendous import. Therefore, they can only be commended if at times they seem extremely rigid in their specifications and over-careful as to the ability and integrity of the pipe fabricator.

Fillets Are of Extreme Importance in All Welds

Design and shapes of fillets are of extreme importance. To approach perfection, the lines of force should be kept as nearly straight as possible. This means making the shape of the fillets gradually sloping without abrupt turns, otherwise under stress the sharp corner checks, gradually throwing the stresses farther inward toward the pipe material itself. This accounts for the shape of the fillets as shown.

It is the writer's belief that adding straps or reinforcements complicates the stresses which are, as proven by these tests, now well harnessed or overcome by careful design and workmanship. Relative tests of normal socket welds as compared with socket welds with pins indicate that the latter usually fracture around the pins before either the joint itself or the pipe fractures. In other words, the addition of the pins apparently added nothing to the overall strength of the joints and detracted something in that a leak was caused to appear around the pins under comparatively lower tensile pull.

Welders Must Qualify by Rigid Tests

Instruction of welders has been many times emphasized and full data is available. Testing of welders is of extreme importance and in addition to having coupons pulled at regular intervals, we have found another test very valuable both to impress the welder with what his work must be made to accomplish and as a practical check upon the general quality of welding. This test is the final practical one used for checking either oxy-acetylene welders or electric-arc welders.

Our standard instructions are: "Each welder, before being considered qualified to operate, must pass the following prescribed test:

"1. Prepare two pieces of 6-in. standard weight pipe, each end bevelled as per our standard and with extra heavy lap joint flanges on the opposite end of each piece to which must be bolted extra heavy blind flanges with a test connection.

"2. The welder must then make a complete butt weld according to our standard specifications. This completed piece must be tested to 750 lb. hydraulic pressure and thoroughly hammered around the circumference of the weld while the pressure is applied.

"3. The sample must then be placed on our bending table with a bending shoe located approximately 6 in. back of the center of the weld and then pulled cold until the pipe collapses practically flat.

"4. After this is done, the weld and pipe are to be examined for any possible cracks and, if the condition of the pipe permits, it is again to be placed on the test rack and hydraulic pressure applied to be certain that there are no cracks in the weld.

"A welder who has successfully passed this test will be considered qualified for independent work on our welded piping."

N. E. L. A. Reports Stoker and Furnace Development

Application of automatic combustion control is the principal phase in the development of stoker equipment and furnaces noted by the N. E. L. A. Prime Movers Committee in its Serial Report on Stokers and Furnaces for June, 1928.

Most of the new installations contain this feature, while many of the older installations are being provided with full or partial automatic combustion control.

Definite data from a number of companies on the operation of automatic combustion control are included this year and the results obtained indicate its utility and value. A number of manufacturers have also contributed statements on their control equipment.

Stoker capacities are increasing to meet the increased demand of heat liberation per square foot of available space. In the design of the newer stoker models, much attention is given to the regulation of air to various parts of the fuel bed. Interesting data on air requirements at various combustion rates are included.

Several statements covering operating difficulties encountered with large stokers and means employed to surmount these difficulties are included this year. Considerable maintenance cost data are also included.

Data on air preheaters include methods, frequency and cost of cleaning and comparative curves on two types of air preheaters.

Preheated air and longer stokers have made water walls increasingly necessary. Few installations are now made without water-cooled walls in some form or other.

Several heat transfer curves and some comparative data on cooled and uncooled walls are included. A number of temperature gradients through bare cast-iron blocks and refractory-faced cast-iron blocks are presented.

Manufacturers are cognizant of the demand for improved equipment and have contributed data on their latest developments.

Better to have no rules than to have rules unenforced.

Reheat Cycle Practice Not Yet Standardized

No Uniformity of Reheating Pressure, Temperature or Practice Is Apparent from Conditions Reported by the N. E. L. A.

IN THIS COUNTRY, five stations are operating on the reheat cycle; two of these, Edgar Station at Boston and Lakeside Station in Milwaukee, have standard boilers and turbines and have added high-pressure boilers of 1200 and 1400 lb. per sq. in. respectively, to furnish steam to a separate high-pressure turbine. This turbine exhausts through a reheater in the high-pressure boiler into a standard-pressure steam main where operating conditions as shown in the table are special.

At Edgar Station, the steam leaving the reheater mixes with the steam which is generated in the standard boilers at about 335 lb. per sq. in. gage before entering the standard 350-lb. turbine. The 1200-lb. turbine is equipped with a pressure reducing nozzle in the bypass line. This bypass is usually cracked open which accounts for the fact that the steam enters the reheater at a higher temperature than it exhausts from the 1200-lb. turbine. In both stations, the high-pressure and standard turbines are distinctly separate units and not two parts of a compound unit.

Three other stations, Philo, Columbia and Crawford Avenue, were designed for high pressure only and have turbines designed for reheating at a certain point in the expansion of the steam. Crawford Avenue has four turbines designed for reheat operation.

No uniformity of reheating pressure or temperature seems to exist between the three stations. At Crawford Avenue, the first three turbines are of different make and this undoubtedly is responsible for the different pressures at the reheaters. Turbine No. 5 will use a steam reheater, but all other reheat units in these three stations have reheaters built in special boilers.

Employment of the reheat cycle is new and no standardized conditions of reheating pressure and temperature has become apparent. If reheating is carried on in reheaters built in the boilers, it would seem advisable to employ as high superheat as possible in the reheater, somewhere in the neighborhood of 700 to 750 deg. F. If, however, reheating is done by steam reheaters, the limiting reheat temperature will range from 495 deg. F. to 568 deg. F. The saturation temperature of steam at 600 and 1200 lb. per sq. in. gage.

Two plants have made no provision for bypassing the reheater but the remaining three stations report that bypassing the reheater has no effect on the satisfactory operation of the low-pressure section of the turbine. At Columbia, the turbines are so designed that they will operate with high or low-temperature steam without difficulty. Bypassing the reheater reduces the maximum load that may be carried by the turbine and considerably increases the water rate.

No Difficulty Experienced with Excessive Superheat

No difficulty with excessive superheat from the reheater and light loads has been experienced at Edgar, Lakeside or Crawford Avenue stations. It is reported that at Crawford Avenue the steam temperature leaving the reheater might rise to 800 deg. F. total temperature before the reheater could be checked, in event of a sudden loss of load.

At Philo the resuperheater at 10,000 kw. load (25 per cent rated load) reached 280 to 290 deg. F. corresponding to a total temperature of about 625 deg. F. When the load goes below 10,000 kw. at Columbia, the reheat boiler is taken off the line and the bypass opened. No difficulty is encountered above this load in firing the reheat boiler to give the desired amount of reheating. Pulverized coal firing makes it possible to maintain constant temperature even with rapid variations in load.

TABULATION OF OPERATING CONDITIONS AT THE FIVE STATIONS USING THE REHEAT CYCLE

Station	Philo				Crawford Avenue					Columbia		Edgar		Lakeside	
Unit Number			1		2		3		5						
Load, kw.	39,700		52,445		57,081		49,213		90,000	46,000		3000 Kw.		7000 Kw.	
Steam conditions	Pres. Gage	Temp. Deg. F	Pres. Gage	Temp. Deg. F	Pres Gage	Temp Deg. F	Pres. Gage	Temp Deg. F	Pres. Gage	Temp Deg. F	Pres. Gage	Temp Deg. F	Pressure Lb. Gage	Temperature Deg. F	Pressure Lb. Gage	Temperature Deg. F.
Throttle, high pressure turbine	556	720	564	664	551	717	554	708	565	750	600	725	1015	703	1220	720
Exhaust, high pressure turbine	136	469	113	372	92	403	122	434	84	375	102	424	380	503	310	460
Entering reheater	136	469	113	372	92	403	122	434	84	375	100	424	368	529	300	460
Leaving reheater	130	726	107	557	89	567	120	652	80	567	96.2	718	355	715	290	725
Entering low pressure section	130	726	107	557	89	567	120	652	80	567	95.6	718	350	693	290	720

AT THE 1928 fall meeting of the American Welding Society in Philadelphia, Oct. 8 to 12, one of the outstanding features will be the exposition. It is expected that the exhibit, which is held in co-operation with the American Society for Steel Treating, will attract a gathering of people interested in the treatment and fabrication of metals, as this combined convention covers the entire metal working field. It will occupy all the floor space of the exhibition hall of the Commercial Museum for 5 days, displaying the best in welding equipment and supplies, also exhibits of welded products.

Technical meetings and registration will be held at the Bellevue Stratford hotel in the morning and at the exhibition hall in the afternoon of each day.

Among the more than 350 exhibitors will be American Brass Co., American Steel & Wire Co., General Electric Co., Lincoln Electric Co., Linde Air Products Co., John A. Roebling's Sons Co., Torchweld Equipment Co., Westinghouse Elec. & Mfg. Co. and Wilson Welder & Metals Co.

Diesel Driven Compressor Serves Quarry

COST OF COMPRESSED air is an important item in quarry operation and air compressors driven by Diesel engines are now showing such low over-all operating costs that they are increasingly becoming popular in quarry, mining and construction work.

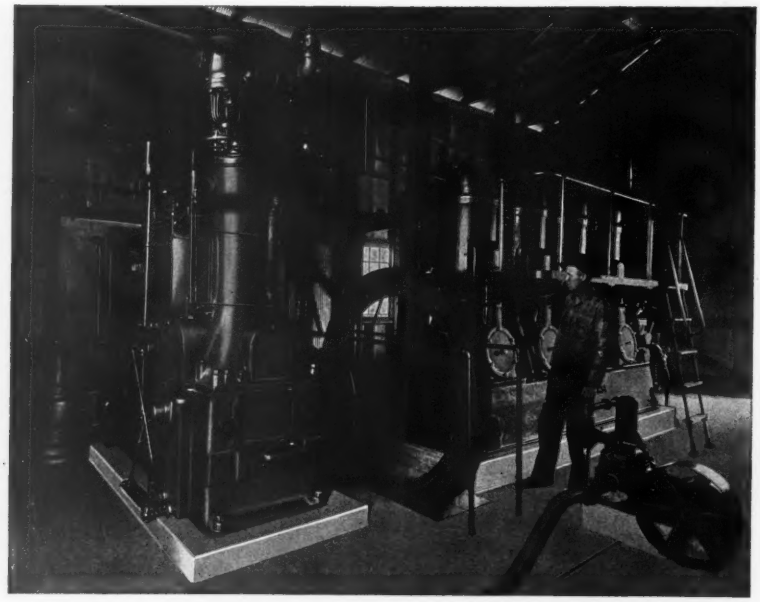


FIG. 1. FAIRBANKS, MORSE DIESEL ENGINE OF 240-HP. IS DIRECT CONNECTED TO SULLIVAN ANGLE-COMPOUND AIR COMPRESSOR

Other advantages of a Diesel operated compressor that are of peculiar importance in a plant of this type are lack of standby loss and ease and speed at which Diesel engines can be brought into operation from a cold start. One of the recent interesting installations of a Diesel driven compressor is at Elberton Quarries at Carlton, Georgia, where a 240-hp. four-cylinder, 2-cycle, single-acting, mechanical fuel-injection Fairbanks, Morse & Co. Diesel oil engine is direct connected to a 22 and 13 by 14-in. Sullivan angle-compound air compressor.

Unit Characterized by Small Number of Parts

Both engine and compressor are self-contained and lubrication is practically automatic. "Wafer" type air actuated valves are used throughout in the compressor, reducing to a minimum the number of working parts requiring adjustment and requiring no cleaning or even inspection except at long intervals.

High speed and angle-compound arrangement permits of large production of compressed air under low space requirement and of direct connection to the Diesel engine. Superior balancing secured by the angle arrangement has so neutralized the opposing forces that the disturbance due to reciprocating forces which cause vibration, is quite uniform throughout a rotation, hence there is no necessity for massive foundation to absorb the unbalanced forces. This reduces the cost and time of installation.

Automatic unloading attachments conserve power and eliminate troubles due to heating when the compressor is running unloaded. Connected to the intake of the low-pressure cylinder of the compressor is an unloading valve and the apparatus is so connected to the air receiver and is so designed that when the air pressure in the receiver has reached a desired limit, the valve automatically shuts off the supply of air to the compressor. This valve is of the double-beat type and is controlled by a pilot valve. When the supply is shut off, the compressor runs under only the load due to friction. In this way, with the rapid fluctuations of demand for air experienced in a quarry, the actual consumption of power is reduced to a comparatively small amount. Net displacement by the compressor ranged from 1224 to

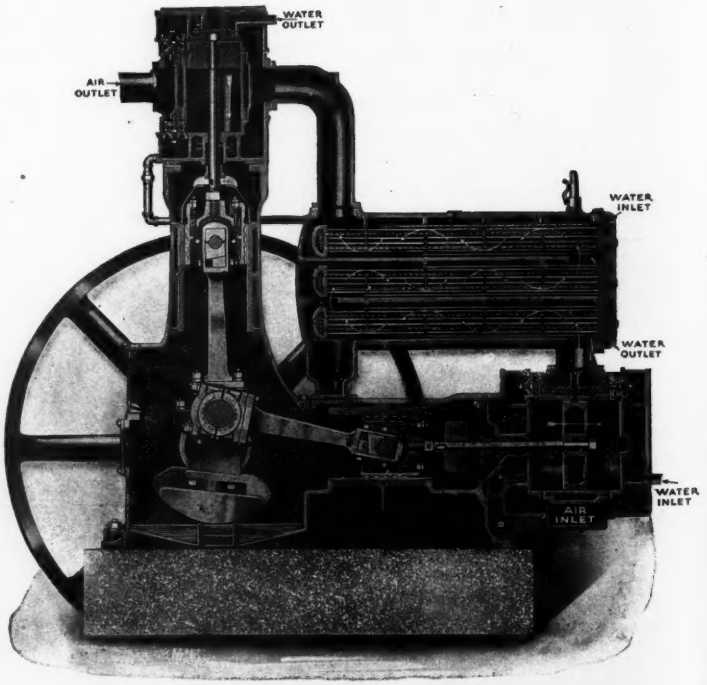


FIG. 2. SECTIONAL VIEW OF SULLIVAN ANGLE-COMPOUND AIR COMPRESSOR SHOWING RELATION OF INTERCOOLER

1573 cu. ft. per min. at 257 r.p.m., the air being supplied through an inlet pipe 10 in. dia., and discharged through a 6 in. dia. pipe.

Granite quarrying requires an abundance of air at high pressure, hence economy of compressed air production is a major factor in quarry operation. After the engine and compressor had been running for a few months a test was made to determine operating costs. It was found that the average daily fuel consumption for a 10-hr. day was 120 gal. and the consumption of lubricating oil 1½ gal.

Economy of Operation

Costs of fuel and lubricating oil were 7¼ cents and 45 cents a gal. respectively. At these rates, the cost of operation per 10-hr. day was $9.40. At that time, the compressor was running under an average load of 40 per cent, the following equipment being operated: Four quarry bar-drills, of 3¼-in cylinder diameter; one tripod-drill of 3-in. cylinder diameter; 15 plug-drills of the "Dallet" type; one Sullivan type "L-5" 75-lb. rotator and one jack hammer.

In addition to the equipment stated, which was operated 10 hr. a day, compressed air was furnished to operate a drill sharpener 4 hr. a day, to sharpen 35 channel and tripod drills and 25 jack hammer drills. A steam hammer, delivering an 800 lb. blow, is operated through a 2-in. line by air, at 100 lb. pressure. In the blacksmith shop are five forges, three of which are now in operation and air is furnished for the operation of air hoists.

Both engine and compressor have been in daily operation since their installation.

High-Pressure Steam Practice Trends*

Theoretical and Practical Limits of Pressure and Temperature. Economic Boiler Capacity and Division of Heating Surfaces

CONSIDERING theoretical cycles, Lord Weir and H. E. Yarrow stated that there is no limit to the pressure that might be used to increase thermal efficiency. Practical use in a steam turbine involves, however, increased expansion with added wetness in low-pressure stages. To avoid this wetness, higher superheat and reheating are necessary, which bring in added problems and complication.

Nozzle and blading losses, disc friction, leakage, complication of stage heating and reheating all are factors.

Examination of the effects of all these shows that possible efficiency increases fairly steadily up to about 1000 lb. per sq. in. Above that, the slight thermal gain is probably too little to justify added cost of plant and operation.

With the limiting cycle initial conditions taken at 1250 lb. and 900 deg. F., two reheatings and eight feed-heating stages, consumption of about 0.37 lb. oil or 0.67 lb. coal might be expected per horsepower-hour. For 500 lb. and 700 deg. F. no reheating, Sir Charles Parsons has calculated that a 5000-hp. turbine might be expected to use 0.57 lb. oil or 0.87 lb. coal per horsepower-hour.

*From papers at the Conference of the Inst. Civ. Engrs., London, England.

Such figures contemplate water-tube boilers with stoker, oil or pulverized fuel firing, air preheaters, possibly 2-stage steam generation.

On the matter of materials, whose characteristics determine an upper usable limit of temperatures, R. G. C. Baston quoted A. L. Mellanby, William Kerr and John Anderson as believing that 900 deg. F. is the highest temperature possible with present steels. The creep or floor effect under continued stress seems to be the limiting factor rather than ultimate tensile stress. The stress at which this creep effect limits safety decreases rapidly after a temperature of 752 deg. F. is passed and, at 977 deg. the working stress may equal the limiting creep stress. Alloy steels may have possibilities but little is known of their action at 930 deg. F. and above.

In boiler capacities, Mr. Patchell stated that units delivering 500,000 lb. of steam an hour are now at work. This is made possible by using pulverized fuel, A-shaped furnaces, U-shaped flames from vertical burners and water-cooled furnace walls. Heating surfaces are divided so that a large portion may "see the fire", thus utilizing radiant heat. Forged steel drums, expanded joints and welding are being used.

For 100 per cent boiler heating surface, maximum figures for added surfaces are: Superheaters, 86 per cent; economizers, 150 per cent; air heaters, 700 per cent; water walls, 60 per cent.

Reduced Air-Mail Rates Effective Aug. 1

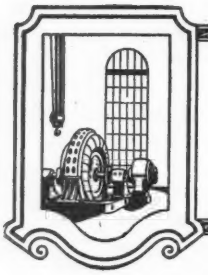
By Arthur C. Lueder, Postmaster, Chicago, Ill.

On and after August 1st, it will cost only one-quarter as much to send the average business or social letter by air-mail as it does now. On that date, the rate will be reduced from 10c a half ounce to 5c for the first ounce or fraction and 10c for each succeeding ounce or fraction. This means that an ordinary letter may be sent anywhere in this country for 5c and that an air-mail package which now requires $2 postage may then be sent to any part of the country for $1.05.

Regulations on air-mail are simple. Any mailable matter (except perishable matter liable to damage by freezing) may be sent by air-mail. Registered, insured and C. O. D. matter is carried by air-mail as are packages not exceeding 50 lb. in weight and not exceeding 84 in. in length and girth combined. Special delivery stamps still further expedite delivery of domestic air-mail.

Air-mail may be deposited in any mail box, but sufficient time should be allowed for collection and transport to the main post office in time for shipment to the air-mail field. Distinctive air-mail envelopes are desirable, but not compulsory, but the words "Air-Mail" or "Via Air-Mail" must be clearly endorsed on the envelope or wrapper.

This new low rate, effective August 1, comes when the air-mail companies are giving the most dependable service in their history. The man or woman using air-mail for business or social correspondence has the benefits and connections of twenty-eight air-mail routes over 12,457 mi., serving 62,000,000 people directly and millions more indirectly.



ELECTRICAL MACHINERY FOR LIGHT AND POWER

Electricity---What It Is and How It Acts*

PART V. MATTER IN THE AGGREGATE. THE THREE STATES OF MATTER. RELATION OF FORCE TO MATTER. THE ELECTRIC FIELD

SOME TIME AGO, Dr. Whitney, director of the General Electric Research Laboratory, delivered a lecture before one of the scientific societies entitled "The Vacuum—There Is Something in It." The point of this lecture was, of course, that even our most perfect vacuums are filled with countless millions of atoms and electrons. Some time afterwards at another occasion in a lecture which he called "Matter—There Is Nothing in It," he pointed out, as we have done in the previous articles of this series, that the stuff which we call matter, consists almost entirely of space. The space occupied by the nucleus and the external electrons of even the most complex atoms is extremely small compared to the size of the atom as a whole. Since all matter is composed of atoms, it follows that matter is mostly space.

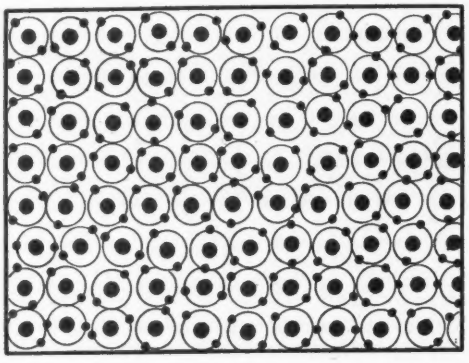


FIG. 1. DIAGRAMMATIC REPRESENTATION OF THE ARRANGEMENT OF MOLECULES IN A SOLID

This represents the arrangements of water molecules in the solid state, i. e., ice. Each molecule consists of one atom of oxygen with two of hydrogen. These are arranged in close proximity, limiting their movement to a small space.

This is of interest in our study of electricity because electricity, as we are ordinarily aware of it, is nearly always associated with matter and if matter consists mostly of space it will be necessary to find out how the electric current manages to flow through or across this space. Electricity, is not always associated with matter, however, as will be seen when we investigate its action in the vacuum tube; in fact, it was only when electricity was first observed apart from matter, i. e., in the vacuum tube, that its true nature began to be suspected. As long as it was confined to solid and liquid conductors, the mystery of electricity was inextricably merged with the mystery of matter. Once, one was observed apart from the other, each became the basis for the explanation of the other.

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MATTER MADE UP MOSTLY OF SPACE

Thus far, we have considered matter only from the viewpoint of its constituent elements, the atom and the electrons. When we come to consider matter in the aggregate, we find that here, too, empty space enters in to a considerable extent. The molecular structure of matter is such that no two atoms or molecules are in permanent contact with one another. Each molecule is separated from its neighbors by a space, inconceivably small as measured by ordinary standards, yet very large compared to the size of the electron. At ordinary temperatures, these molecules are in constant state of agitation, each undergoing millions of oscillations per second and colliding with its neighbors as often. Heat, as we know it, is in reality a manifestation of this vibration.

As a body is warmed, more energy is imparted to the molecules and they vibrate more actively; as a consequence, the force of collision between molecules is greater and they tend to occupy more space. This makes the body become larger as it is warmed, a phenomenon we ordinarily term thermal expansion.

THREE STATES OF MATTER ACCOUNTED FOR BY MOLECULAR ACTIVITY

Matter may exist in either of three states: 1, as a solid; 2, as a liquid, and 3, as a gas, depending upon the temperature. At low temperatures, all matter becomes solid while at high temperatures it becomes gaseous. As the heat energy content of a body is progressively increased, it passes from a solid into a liquid and finally into a gaseous state.

In solids, the molecules are relatively close together and are bound together by powerful attractive forces. While there is incessant agitation among the molecules, they make only small excursions from their mean position. As the temperature is increased, the agitation of the molecules is increased, the mean free path between collisions becomes longer and the cohesive force between

them is almost lost. Naturally, liquids will assume the shape of any vessel into which they are placed. With a still further increase in temperature or heat energy content, the cohesive force between molecules is lost entirely and they tend to knock one another as far apart as possible. When this condition is reached, the body is in the gaseous state and the molecules will no longer remain within the vessel in which they are placed unless restrained by solid walls. The combined force of all the molecules impinging against the sides of the containing vessel in the case of a gas, is a measure of the gas pressures. The greater the number of molecules per unit of volume and the greater their speed (and also their kinetic energy) the greater will be the pressure.

Thus the three states of matter are simply accounted for by the difference in molecular agitation. In different elements, the transition points between the solid, liquid and gas states vary greatly. In the case of helium, the transition point between liquid and solid is 271 deg. below zero, Centigrade, while with tungsten, it is 3400 deg. above zero, Centigrade. Water, at atmospheric pressure, passes into a gas at 100 deg. Centigrade, while for platinum a temperature of 3910 deg. C. is necessary. In each of these cases, however, the principles underlying the changes are the same.

In considering matter as a conductor or carrier of electricity, we have three classes of conductors, solid, liquid and gaseous. The type of conductor we are most

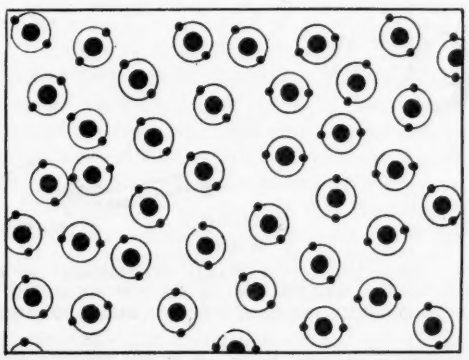


FIG. 2. MOLECULES OF WATER IN THE LIQUID STATE

Here, compared with Fig. 1, the molecules are farther apart and the attractive force between them has almost disappeared.

familiar with, of course, is the solid conductor, usually in the form of copper wire or cable. Conductors of the second class are those to be found in primary and secondary electric batteries, electrolytic rectifiers and condensers, and in electroplating apparatus. The third class of conductor is best exemplified by the mercury vapor lamp and the electric arc.

As indicated in Part I, in the early days of electrical service it was difficult to reconcile the theories which had been developed for conduction in solids and in liquids. Two theories had been developed, neither of which would fit the other case. It was not until the third class of conduction began to receive attention, and then only because it became apparent that there was still another class of conduction, if it might be called such, which depended upon neither of the three types of conductors, but involved what was apparently a fourth state of matter. It seemed that the electric current was able to bridge spaces where there was no matter. This, as has been pointed out, led first to the conception of the electron and finally to its discovery.

We have, in the course of this discussion, referred to the attractive forces between atoms and molecules and electrons. Now when we speak of force, most of us think we know what the term means, but when we try to define it and to form an idea of it in our minds, we are compelled to admit that the idea of force is somewhat vague. Force is entirely a subjective concept without any reality. When we cause a body to alter its state of motion, either by changing its speed or its direction, we say that we exert a force. Yet, the body after the application of this force has undergone no change

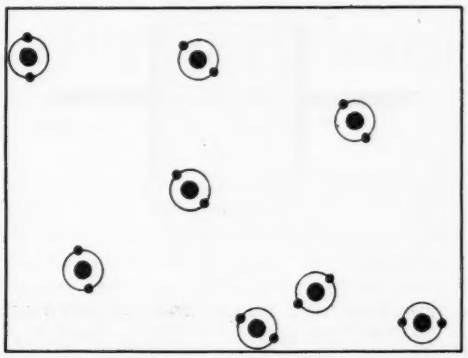


FIG. 3. MOLECULES OF WATER IN THE GASEOUS STATE

In the gaseous state all attractive force between the molecules has disappeared and they are spaced at relatively great distances.

except in the total amount of available energy it may possess. Whatever may be the alteration in the body due to the application of a force, the alteration is but the manifestation of a change in the disposition or availability of that incomprehensible entity we call energy.

So, in our consideration of electricity and the structure of matter, it is necessary to include the concept of energy. Energy and electricity, in fact, are the two postulates in terms of which all things in the universe must be explained. These two entities, furthermore, are probably convertible. The idea that energy may be converted into matter and vice versa is relatively new but, no doubt, will have far-reaching results upon future scientific thought. Already it seems to give us the clue to the secret of the sun's energy.

It seems that to every particle of moving matter in the universe must be ascribed a certain amount of energy. The amount of energy possessed by any particle depends upon its speed relative to other particles, and its electrical characteristics. Thus, when we speak of forces existing between atoms and molecules and electrons, we are referring to the relative available energy they possess. Two atoms, for instance, attract each other with a certain definite force. If no other restraining forces are acting upon these atoms and if they are permitted to come together, a certain amount of energy will be liberated. Similarly, to pull the two atoms apart requires the expenditure of a certain definite amount of energy.

In the case of hydrogen, for instance, at ordinary temperatures, the atoms of hydrogen always combine in pairs to form molecules. At extremely high tempera-

tures, however, the molecule is dissociated into single atoms, which, however, will recombine into molecules of two atoms each when the temperature decreases. This fact is made use of in the recently developed atomic hydrogen welding process. In this process, a stream of hydrogen gas is forced under pressure between the electrodes of a powerful electric arc. In the arc, due to the extreme temperature, the normal hydrogen molecules are dissociated into single atoms of hydrogen and in this state are forced beyond the limits of the arc. Once outside of the arc the temperature drops and because of

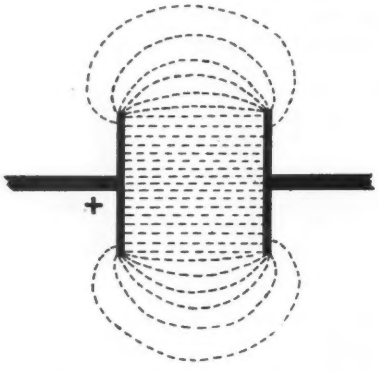


FIG. 4. THE ELECTRIC FIELD EXISTING BETWEEN TWO OPPOSITELY CHARGED METAL PLATES

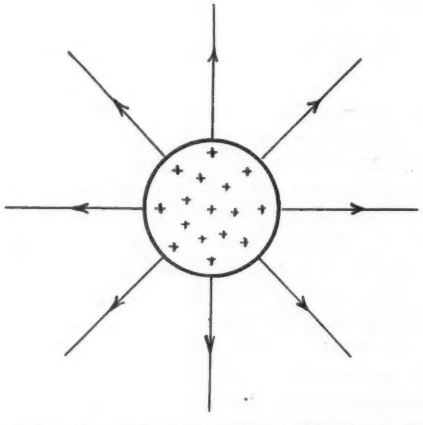


FIG. 5. THE ELECTRIC FIELD SURROUNDING A CHARGED METAL SPHERE ISOLATED IN SPACE

this the separate atoms of hydrogen combine again into molecules of two atoms each. In this recombination, they release the energy which was absorbed in the process of dissociation in the electric arc, resulting in the production of extremely high temperatures.

One of the things we are interested in in our study of electricity, is the nature of the force which enables atoms and electrons to attract or repel each other. In what way is the force between two such elements transmitted across the space which separates them?

It has been shown that when a stick of sealing wax is rubbed with a piece of flannel, both the flannel and the wax become charged, one negatively and the other positively. This charge, we know, is due to some of the electrons having been rubbed off the atoms composing the flannel and left on those of the wax.

If now the wax is approached to the flannel, it will be found that an attractive force exists between the two. This force exerts itself even though the two substances are not in actual contact.

The effect is even better illustrated by suspending a light substance such as a pith ball from a fine thread and touching it with a charged body, say the stick of sealing wax. It will be found that the pith ball becomes charged with electricity of the same polarity as that of the wax, and since like charges repel each other, the pith ball will be repelled by the sealing wax. By experimenting, it will be found that the repulsive force is present even though the pith ball and the wax are at a considerable distance from each other. Evidently the space surrounding the charged bodies is under some kind of strain which enables it to act upon the charged bodies with a force, attractive or repulsive depending upon the relative polarities of the charges. This space

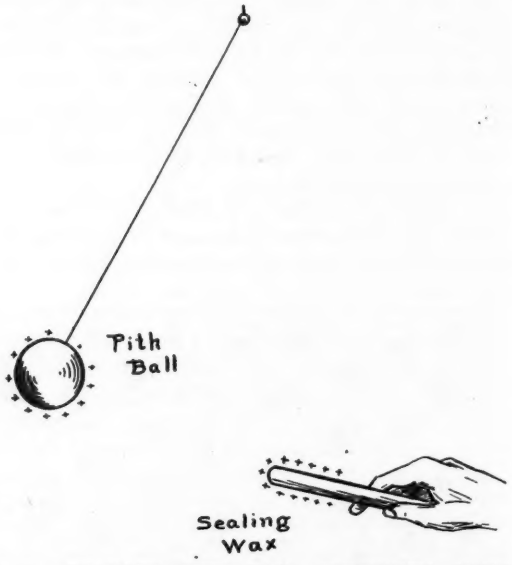


FIG. 6. CHARGED PITH BALL SUSPENDED FROM A THREAD IS REPELLED BY STICK OF SEALING WAX CHARGED WITH ELECTRICITY OF SAME POLARITY

surrounding a charged body, in which another charged body is acted upon by a force tending to move it, constitutes an electric field, sometimes called an electrostatic field.

Lines of Force and the Electric Field

The exact nature of an electric field is not known, but it is convenient to think of it in terms of lines stretched between the oppositely charged elements. The direction of the line, properly drawn, gives the direction of the force at any point and their closeness to each other shows the relative strength.

In Fig. 4 is illustrated the electric field between two oppositely charged metal plates. Directly between the two plates the lines of force are straight and are also most intense. At the edges, the lines are curved and less numerous, indicating a field of lower intensity.

Figure 5 shows a positively charged metal ball, which we may conceive as being isolated in space, far from any other charged bodies. Under this condition the lines of force are shown extending radially outward from the sphere. The arrows on the lines indicate the direction in which a positive charge would be urged if

placed in that portion of the field. While the lines are shown ending in uncharged space, in reality each line would terminate somewhere upon a negative charge.

Whether any such lines of force as we have described actually exist and if they do, what medium they are composed of, nobody knows at present. At one time, before the days of Einstein, we used to believe—for now we are not sure whether we believe it or not—that these lines were lines of strain in the ether. The ether was a hypothetical medium which was supposed to exist throughout all space, even between the atoms and between the electrons of all matter.

Since the more or less general acceptance of the Einstein theory and the quantum theory, the need for this ether is not so essential as it once was, although the ether theory cannot yet be said to have been superseded.

For the present, however, it will be convenient to assume the existence of the lines of force, since such an assumption will be helpful in explaining electrical phenomena. Each electron, that is each unit electric charge in the universe, it will be assumed, has attached to it lines of force which enable it to act at a distance upon other oppositely charged elements. This conception will not only enable us to overcome some of the difficulties of explaining "vacuums with something in them" and "matters with nothing in them", but will also give us a means of accounting for the operation of generators and motors and electric door bells.

Transformer Losses Due to Higher Harmonics

Analytical Study Shows That a Wattmeter Will Record Losses Due to Different Harmonics of No-Load Current. By A. Naeter*

WHILE TEACHING at Cornell University a few years ago, a question was raised by a student as to whether or not a wattmeter would record the copper loss due to the third harmonic component of the magnetizing current of a transformer when tested for its no-load losses.

In the analytical treatment of a transformer for its no-load characteristics, it is generally assumed that a sinusoidal voltage is applied to the transformer winding. The wave form of the magnetizing current can be determined from an oscillogram or by a combination of the voltage wave form and the hysteresis loop. When hysteresis is present, the iron may or may not be saturated, the magnetizing current wave form becomes distorted. Mathematically (by means of a Fourier Series analysis) it can be shown that this distorted current wave generally contains a prominent third harmonic as well as higher harmonics. Consequently, the situation arises, according to the original assumption, of having a fundamental and a third harmonic of current (neglecting the higher harmonics for the time being) in the current coil of the wattmeter, that is being used to measure the no-load losses, and presumably a sinusoidal voltage of fundamental frequency applied to the potential circuit of the same meter.

Frequencies of Currents in Potential and Current Coils Must Be the Same

It is a well-known fact that a wattmeter will give an indication only provided the frequencies of the currents in the current and in the potential coils are the same. Consequently, it would appear, upon first thought, that the wattmeter will not record the copper losses due to the third harmonic of current in a no-load transformer test.

If stated in its most general form, it might be assumed that the transformer were connected to an infinite bus of sine-wave e.m.f.; however, the generating equipment available as a source of power to the average transformer testing laboratory does not have the characteristics of an infinite bus.

The voltage wave of modern alternators is nearly sinusoidal. Let it be assumed, for the sake of analysis, that the wave form of the induced voltage is sinusoidal; and that the alternator is of the non-salient pole type. In this case the armature reaction of the load current will not produce any distortion in the induced voltage wave form, since this distortion arises generally from the different effects of the components of the armature reaction acting upon the poles and the interpolar spaces in salient pole machines.

Effect of Applying Voltage to a Transformer

Upon applying a voltage of this alternator to a transformer at no-load, it will be found that the magnetizing current is distorted and contains higher harmonics due to the presence of hysteresis. When the voltage is sufficiently high to produce saturation, the distortion becomes more marked. Due to the inductive reactances and resistances of the alternator and the supply circuits there will be a voltage drop.

The wave form of the voltage drop due to the resistance will have the same shape as that of the current, because the resistance is a constant quantity. The component of voltage drop across the inductive reactance is proportional to the change in current and the inductive reactance. This inductive reactance is directly proportional to the inductance which may or may not be a constant quantity. In the line part of the circuit the inductance is a constant quantity, while in the iron portion, e. g., the alternator, the inductance decreases as saturation is approached. When the alternator is sufficiently large to reduce saturation effects caused by the current supplied to the transformer, the inductance of the circuit, including the generator, up to the transformer terminals may be taken as a constant quantity. (Numerous authors have pointed out that the leakage flux per ampere per unit length of conductor in the armature of an alternator may be considered as a constant quantity. On this basis, the alternator leakage inductance may be assumed to be constant.) Then the inductive voltage drop is directly proportional to the rate of change of the current. Combining these two components of voltage drop, when the current wave is

*Associate professor of Electrical Engineering, Michigan State College.

sinusoidal, the voltage drop is sinusoidal; but when the current wave form is distorted, the voltage drop wave form is distorted. Consequently, it is apparent that in a no-load test of a transformer that the resultant wave form due to the two components of voltage drop is a distorted one. Upon subtracting this irregular wave form of voltage from the induced sinusoidal generator voltage, the resultant voltage applied to the transformer terminals will no longer be sinusoidal.

It should be indicated at this point, without going into details, that the application of this irregular wave form of voltage to the transformer terminals will produce an exciting current whose wave form is more complex than that produced by a sinusoidal voltage.

This qualitative discussion shows that the original assumption of a pure sine wave voltage applied to the potential terminals of the wattmeter and a fundamental frequency and a third harmonic current in the current coil during a no-load test of a transformer is wrong. In other words, when the current coil of the wattmeter carries a fundamental and higher harmonics of current, corresponding frequencies will be present in the voltage form applied to the potential circuit of the same meter.

It should be remembered that the proponents of the infinite bus point of view would claim, and rightly so, that with the transformer connected to an infinite bus of sine wave e.m.f., it would be possible to have a sinusoidal voltage across the potential element of the wattmeter while the current coil carried a current containing the fundamental frequency and higher frequency components. However, as stated previously, the average testing laboratory source of energy does not approximate an infinite bus.

It remains to be shown that the phase relationships are such that the energy losses caused by the higher harmonic components of the current are recorded by the wattmeter:

Let $e = E_1 \sin a_1$ = the induced voltage of the alternator, and

i = the no-load current of the transformer

$= I_1 \sin (a_1 - \phi_1) + I_3 \sin 3 (a_3 - \phi_3) + \ldots\ldots$

Then the impedance drop due to the resistances and inductive reactances, respectively, of the generator and the line is

$$e' = I_1 Z_1 \sin (a_1 - \phi_1) + I_3 Z_3 \sin 3 (a_3 - \phi_3) + \ldots$$

where Z_1, Z_3, etc., represent the impedances corresponding, respectively, to the fundamental, third harmonic, etc., components of the exciting current. This is on the assumption that the alternator is large as compared to the transformer, and that, as a result, the alternator reactance may be considered a constant quantity without introducing appreciable inaccuracies. Then the voltage applied to the transformer terminals is $e - e' =$

$$E_1 \sin a_1 - [I_1 Z_1 \sin (a_1 - \phi_1) + I_3 Z_3 \sin 3 (a_3 - \phi_3)] \ldots$$

$$= E' \sin (a_1 - \phi'_1) + E_3 \sin 3 (a_3 - \phi_3) - \ldots\ldots$$

This latter expression can be put into a form that is more convenient from the standpoint of the study of the losses in the transformer. Then e_t = transformer terminal voltage

$= E' \sin (a_1 - \phi'_1) + E_3 \sin 3 (a_3 - \phi'_3) + \ldots\ldots$

Both the terminal voltage of the transformer and the no-load current are represented by Fourier Series expression as follows:

$e_t = E' \sin (a_1 - \phi'_1) + E_3 \sin 3 (a_3 - \phi'_3) + \ldots\ldots$

$i = I_1 \sin (a_1 - \phi_1) + I_3 \sin 3 (a_3 - \phi_3) + \ldots\ldots$

In evaluating the integral of the product $e_t i$, to determine the average power consumed in the transformer, two forms of expressions appear, one involving the product of two terms of the same frequency and the other of different frequencies. The former reduces into the familiar single-frequency form for power and the latter becomes equal to zero. Hence, the average power consumed in the transformer becomes

$$P_{ave.} = \frac{E' I_1}{2} \cos \phi''_1 + \frac{E_3 I_3}{2} \cos \phi''_3 + \ldots\ldots\ldots$$

Hence, it is apparent not only that the wattmeter has the corresponding frequencies in its current and potential coils, but also that the phase relationships are such that it records the losses due to the different harmonic components of the no-load current, of which losses the copper losses are only a part.

In the case of the transformer connected to an infinite bus, it can be shown that the wattmeter records the total power loss even though the voltage coil does not contain the harmonic components corresponding to those present in the current coil.

The Calculating Table

SEVERAL YEARS AGO, in attempting to avoid the intricate and tedious calculations necessary to determine short-circuit currents in a large system, a simple solution was discovered. This consisted in setting up the system connections on a miniature scale and trying out the desired short circuit, reading the result directly by means of a sensitive ammeter. It was for this purpose that the "calculating table" was designed and built by the General Electric Co. The board shown in the accompanying illustration is used extensively in solving many problems of the Outside Plant Bureau of the Brooklyn Edison Co.

To the casual observer who is confronted by this table, it is indeed a complicated and mysterious object. In appearance it resembles a combination of gigantic radio set and telephone switchboard. Each of its 136 dials controls a variable resistance inserted between two of the plug connections. The milliammeter, which is set into the desk, may be connected in any one of the resistor circuits by merely pressing the proper push button. The plug board serves to connect the resistances together in any desired combinations to represent the particular circuit under consideration.

This arrangement solves the most intricate interconnection problems with ease. Inasmuch as some of the solutions would require hours of mathematical and algebraic manipulation and others are practically impossible, a great saving of time and effort may be credited to the table.

The original use for which this instrument was intended involved the determination of all sorts of short-circuit conditions on the 27,000-v. or 4150-v. systems in order that adequate switching apparatus might be

purchased and proper relay settings established. Since high tension switching apparatus is expensive and represents a large investment, accurate and complete information is essential. If switches are purchased which are too small for the tremendous short-circuit currents available from Hudson Avenue, there is a possibility of destroying not only the switch but some of the connected apparatus as well, while, on the other hand, if the switches are oversize, unnecessary investment is incurred.

Recently another use has been found which could hardly have been anticipated at the time of purchase of the table. With the installation of the modern, low-

CALCULATING TABLE AT THE BROOKLYN EDISON CO.

voltage, alternating current networks, problems continue to arise that are practically impossible of mathematical solution.

In network planning, it is desirable to know to what extent transformers and mains will be loaded and also what voltage each customer will receive. If a miniature replica of the network is set up on the table, using resistors to represent mains, transformers and loads, the currents carried by the artificial system will be proportional to the corresponding currents in the actual network. In other words, the conditions which are expected to obtain when thousands of dollars' worth of copper are installed in the streets and hundreds of kilowatts are being distributed, can be studied in detail in advance of installation.

Answers obtained by means of the table are always in terms of load currents. This determines immediately any condition of overload. By a very simple calculation, voltages may be determined after the loading of the network mains is known. In this way, it is possible to detect in advance any conditions that might result in poor service or to determine the minimum installations necessary to give adequate service.

Another phase of network calculations, easily taken care of by the table, is what is known as "emergency conditions." In any electrical system occasional failures of cable or other equipment are inevitable and in network especially it is necessary to know what loads and voltages obtain when one of the parts is removed from service. Frequently there are several possible conditions which must be investigated. This is done on the table merely by removing the unit which represents the faulty apparatus and in a few seconds the "emergency" values are ready for recording.

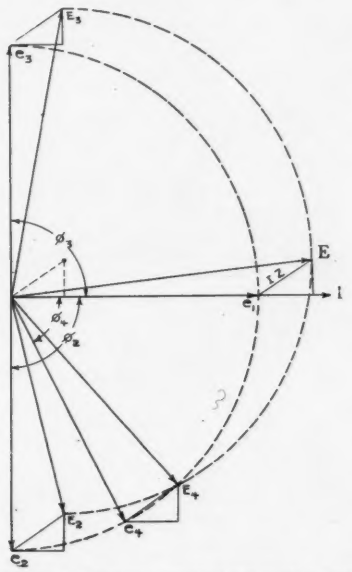
The major contribution of the table to the company's system is the elimination of guesswork or approximation in advanced planning. Long before equipment is installed, future conditions are predicted and any necessary steps may be taken to reinforce any weak unit in the layout.

For the foregoing details, we are indebted to Stanley A. Tucker of the Brooklyn Edison Co.

Line Voltage Conditions at the End of a Transmission Line

By Carl W. Evans

WHILE MAKING a voltage survey on the primary distribution lines of a southern utility, a foreman was somewhat puzzled at finding the voltage at the end of a particular line higher than that impressed upon it



CIRCLE DIAGRAM SHOWING VOLTAGE RELATIONS UNDER VARIOUS CONDITIONS

at the plant. An investigation into the conditions and characteristics of the line and load explained the cause of this unusual situation.

This line was constructed in such a manner, and was of such length, that the impedance was composed mostly of inductive reactance, the capacitance of the line being negligible. The IZ component of the impressed voltage, that is, the part of the impressed voltage utilized in overcoming the impedance of the line, therefore, was considerably ahead in phase of the load current. The load upon this feeder was a bank of synchronous motors of a cotton mill and it was found that these motors were being operated with their fields con-

siderably over-excited, which resulted in a load current leading the terminal voltage by a large angle.

The accompanying circle diagram illustrates how it was possible, under the conditions described, to have a voltage at the end of the line higher in value than that impressed upon it.

In the diagram, the load current, I, is taken as a reference vector. Assuming the power factor of the load as unity, the voltage at the end of the line would be e_1. The impressed voltage would be E_1, which is the vectorial sum of e_1 and the IZ drop of the line. In this case the impressed voltage would be greater than the terminal voltage, as indicated in the circle diagram.

If, however, the power factor had been cos ϕ_2, that is, if the load had been highly capacitive, then the terminal voltage would be e_2 and the impressed voltage, E_2, would be the vectorial sum of e_2 and IZ, in which case, of course, the numerical value of E_2 would be less than that of e_2.

As the phase angle, ϕ, between the load voltage and current decreased, E would increase until, at the angle of ϕ_4, it would exactly equal e. For all other values of ϕ the impressed voltage, E, would be greater than the terminal voltage, e.

Edgar Extension Confirms High-Pressure Claims

HIGH PRESSURE EQUIPMENT DEMONSTRATED SUCCESSFUL IN OPERATION AND NEW CONSTRUCTION PROVES ECONOMY OF 1200-LB. CYCLE

LINGERING DOUBTS as to the practicability of high-pressure operation are being dispelled by the numerous installations completed, contemplated or under construction. Perhaps the most convincing argument as to the work of the 1200-lb. cycle is the recent completion of the first extension to Edgar Station, with the announcement of a new high-pressure addition for Lakeside.

Both of these stations have had sufficient experience with the new equipment to prove that it can be operated successfully and economically. First costs are but slightly higher than for lower pressures, and the increased fuel economy is considerable. Detailed studies at Edgar to determine the proper pressure for the extension showed that an all 1200-lb. pressure plant would give, all things considered, the lowest cost per kilowatt-hour on the station bus.

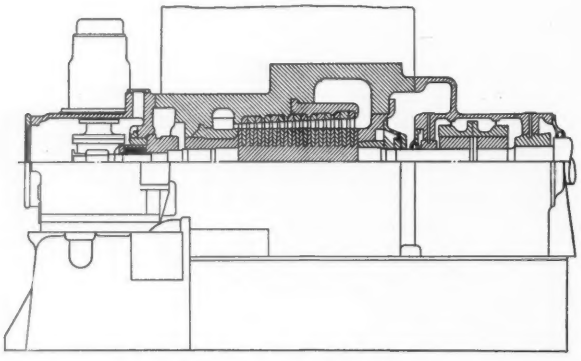


FIG. 1. CROSS SECTION OF 16-STAGE, 10,000-KW., 1200-LB. TURBINE IN THE EDGAR STATION

RAPID PROGRESS ALSO AT NORTHEAST AND DEEPWATER

In addition to these two stations, the rapid progress being made at Northeast and Deepwater stations is further argument that the 1200-lb. pressure is definitely established and, although admittedly not economically applicable to all conditions, developments of larger units and increased production allowing manufacturers to reduce costs should rapidly widen the field.

Nor have all the high-pressure installations been confined to central station practice. In Europe, industrial plants have taken the lead in high-pressure development, while in this country two high-pressure industrial boiler units are in service and negotiations for 2300-lb. industrial installation of foreign equipment for the Middle West are reported closed.

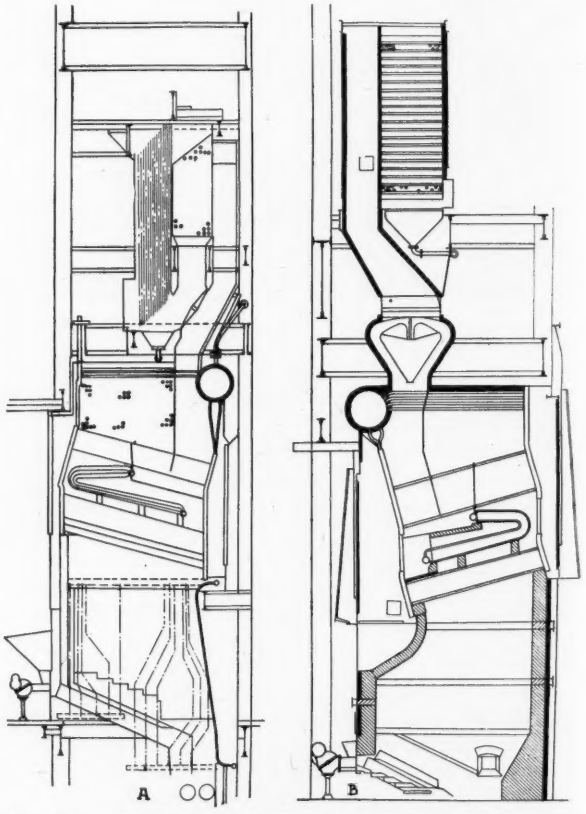


FIG. 2 A. CROSS SECTION OF THE TWO 1400-LB. BOILER UNITS AT EDGAR. B—CROSS SECTION OF THE ORIGINAL HIGH-PRESSURE UNITS

In the extension to Edgar Station are installed a 16-stage, forged-steel, 10,000-kw., 1200-lb. G. E. turbine, shown in Fig. 1, and a 65,000-kw., 350-lb., single-barrel, single-flow, 1800-r.p.m. unit. Steam is supplied by two

Babcock & Wilcox boiler units, shown in cross section in Fig. 2, which is reproduced from the recent N. E. L. A. report on "Stokers and Furnaces."

Details of Construction of New Edgar Boilers

These boilers are built for 1400 lb. per sq. in.; the inner diameter of the seamless forged steel and water drums is 48 in. and the thickness of the steel is 4⅝ in. The lower deck of eight rows of 3¼-in. tubes, 19 ft. long, is connected to vertical headers and the upper bank of ten rows of 2-in. tubes, 17 ft. long, is connected to inclined headers. Each boiler has a heating surface of 16,093 sq. ft.

Superheaters are designed to give a steam temperature of 729 deg. F. at maximum capacity. Steam makes three passes through the superheater, the hottest steam going through the section made up of alloy steel tubes. This alloy is a chromium steel and its carbon content is less than 0.1 per cent with a chromium content of 16.5 to 18.5 per cent.

The reheater is placed above the uppermost bank of boiler tubes and the damper is raised and lowered between the two banks to regulate the temperature of the leaving steam and to reheat it. Two sets of U-tubes are used in the reheater connecting the two headers at each side of the setting. Steam flows in parallel. This arrangement is somewhat different from that used in the old high-pressure boilers, where the reheater tubes extended completely across the boiler setting. Temperature of superheated steam from the reheater is to be maintained at 750 deg. F.

Stokers Are Unusually Long

Each boiler is fired by a 16-retort, 45-tuyere, Taylor underfeed stoker, designed to evaporate 270,000 lb. of water per hour continuously. This is said to be one of the largest underfeed stokers in service today. To accommodate the long stoker, which extends beyond the length ordinarily considered possible in a furnace of this type, an inclined water wall has been used.

These stokers are fitted with unusually large renewable feed and crusher rolls, extending out at least 2 in., as compared with the ordinary depth of about 1 in. and they are secured in place by steel bars instead of the cast iron construction formerly used. The original boilers had 15-retort, 29-tuyere stokers with a capacity of about 121,400 lb. of steam per hr.

Comparison of New High-Pressure Boilers with First Installation

As built with 2-in. tubes throughout, the original boilers gave considerable trouble from slag bridging across the tubes next to the furnace. The difference in boiler and furnace design in the original and new units is apparent from a comparison of Fig. 2A and Fig. 2B. The boiler heating surface was 15,732 sq. ft., with 11,110 sq. ft., or 70.6 per cent of economizer surface. These units were designed to evaporate 9.1 lb. per hr. per sq. ft. of boiler heating surface as compared to 16.6 lb. per hr. per sq. ft. of boiler heating surface of the new units.

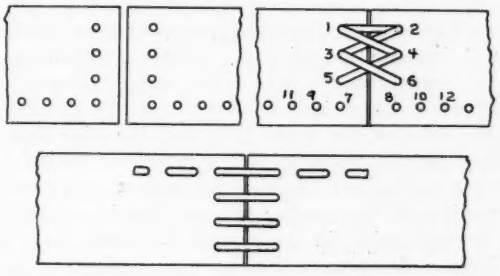
Two motor-driven and one steam-turbine-driven boiler feed pumps are installed to supply feedwater sufficient for a load of 89,000 kw. and a maximum pressure of 1600 lb. per sq. in. Motor-driven pumps are for normal operation and the turbine-driven unit is for emergency service. The capacity of each unit is about 900,000 lb. per hr.

For feedwater heating, the 350-lb. turbine will be bled at three points and the exhaust of the high-pressure turbine will also be bled for this service at approximately 370 lb. The high-pressure heater is designed so that water at approximately 420 deg. will be fed to the economizers.

Belts Laced Properly

ONE OF THE simplest and most effective of strong lacings is shown in the accompanying line drawing, given the writer by E. F. Jackson, a maintenance engineer in a large plant in Bridgeport, Conn.

By means of a sharp knife and a square the ends of the belt are cut straight and clean. Using the measurements on the square, carefully space the holes,



EVENLY SPACED HOLES AND A GOOD LACING SYSTEM

making certain that ample space has been allowed between rows to insure full belt strength. On a 6-in. belt, the holes should be about 1 in. from the end.

When the holes have been punched as indicated, the laces can be inserted through holes Nos. 1 and 2, with the ends on the inside, drawn up so that the exact center of the lace will form the first connection. The laces are then brought back through the same holes, the ends crossing on the face side. Now pass the laces down through holes 3 and 4, crossing them to be brought back through the same two holes, for similar insertion through holes 5 and 6. By repetition of this process all of the holes across the end of the belt are laced, with the final ends of the laces made fast by insertion through holes 9, 10, 11 and 12 as indicated.

This plan of lacing calls for the crossing of laces to be done entirely on the back of the joint, which does not come into contact with the pulleys. It will be found also that, when the laces are turned about one another on the pulley side, a mixed surface of the laces bears on the pulley. The advantage of this is that even though one part of the lace may become worn, it will be supported by the neighboring part, hence this type of joint, in addition to minimizing the danger of fraying, stretching, or tearing, will wear for a long period.

According to H. M. Martin, the work of the Nozzles Research Committee of the Institution of Civil Engineers has resulted in increasing the hydraulic efficiency of steam turbine impulse blading by 5 to 6 per cent.

Principles and Design of Surge Tanks*

PART III. MODIFICATIONS TO CALCULATION FOR SIMPLE SURGE TANK SHOW HOW ITS PERFORMANCE CAN BE IMPROVED. BY JOHN S. CARPENTER

IN THE SECOND ARTICLE of this series on the principles and design of surge tanks, we closed with the statement that we would later consider corrections to our first given method of design and would discuss means to overcome some of the undesirable features of the simple tank. We saw how wildly the simple tank overshoots the mark when taking on 500-c.f.s. increase and we did not go into the fact that simple tank would have been shown up still more unfavorably by assuming large load changes on and off at regular intervals. To go further into that matter is not our present purpose, as it is plain that the simple tank is not suited for the conditions.

We have all noticed how the needle of a pressure gage will dance when the gage is connected to the discharge line of a reciprocating pump and we recall the natural impulse to quiet the needle by choking the passage connecting the gage to the pump discharge. We shall here and now imitate that process by choking the passage between the surge tank and the pipe line and we shall see that remarkable and extremely desirable results are so obtained. Choking the pressure gage steadies the reading of the needle; this choking is beneficial up to a certain point, in the case of the surge tank, as it produces a damping action by means of pressure differences so created, enables the tank to get into action much quicker and allows a smaller tank to be used for a given degree of regulation stability.

CALCULATION OF SIZE OF RESTRICTING ORIFICE FOR SIMPLE TANK

Our original requirement was that the head was not to be drawn down more than 20 ft. Allowing 4.0 ft. for the friction plus the velocity heads and arbitrarily adding another foot to make the total 5.0 ft. (the purpose of which will be appreciated later), we have left a net accelerating head of 15.00 ft. We will allow the water in the pipe line to get into or out of the surge tank only through an orifice cut through the wall of the pipe. For the present, we will assume that the orifice has a discharge coefficient of 100 per cent, and when we come to the detail design we will use a coefficient of 60 per cent to find the area demanded by practice.

Now, what sized orifice will discharge 500 c.f.s. under 15-ft. head with a discharge coefficient of 100 per cent? Here we can assume that the water will flow through with spouting velocity due to the head and, for 15-ft. head this velocity is 31.1 ft. per sec.; therefore it requires a discharge area of 500 ÷ 31.1, or 16.1 sq. ft. We see, therefore, that forcing 500 c.f.s. through such an orifice requires 15-ft. head and in this case we agree that it is a head drop as concerns the pipe line.

If we now apply the step-by-step method of computation given in Part II of this series, we will find, at any instant of time, that the net accelerating head is the head drop, figured as just indicated, plus the drawdown in the tank, less the friction head at the velocity then existing.

It is indeed a pleasure to find that the total net accelerating head for this condition is practically constant throughout the accelerating period; using two-second intervals, the total accelerating head does not vary from 15 ft. total by as much as 0.50 ft. Then to figure the accelerating time is very simple and, by the formulas given in Part I, we find it to be 51.7 sec., considering the head drop as 15 ft. constant over the whole time. We had better not try to refine this too much, for our case is already idealized to some extent, as indicated in Part I, for greater ease in getting a mental picture of this problem. The whole matter is now greatly simplified and the reader who wishes can carry out computations for this new condition. He will find that the final drawdown of the water surface in the tank at the end of successive waves will not increase as it did in our simple tank but will die out rapidly, as it should for good regulation.

RESTRICTING ORIFICE EFFECTS GREAT IMPROVEMENT IN TANK ACTION

Now let us sit back in our chairs and criticize what we have done. Neglecting the effects of governor action, which softens the blow on the tank in that the full 500 c.f.s. is not demanded instantly due to the 3 sec. governor time, we see that the pressure drop of 15 ft. due to the orifice comes about almost instantaneously. This alone is some 30 per cent of the effective head.

For the excessive requirement of full load water quantity at once, this does not seem too much, as commercial load changes are nothing like that amount and are more gradually applied. Approximately, we can assume that the head drop for loads taken on will vary as the square of the water quantity or still more roughly, as the load and, for taking on 250 c.f.s. we should find the head drop one quarter of the drop for 500 c.f.s. In our case, 250 c.f.s. would correspond to about half load and the corresponding head drop being a quarter of 30 per cent (for 500 c.f.s.), we find that the tank will do very well.

Ordinarily surge tanks are not designed to provide water for more than half load when the plant in question is tied in with others and for isolated plants only when the load variations are severe. In considering severe load changes, it should be recalled that the required power for starting certain types of electric motors is considerably more than their normal full-load current when such motors are direct-connected to their loads.

Sudden head drop for the tank using the orifice mentioned could be somewhat further delayed and more gradually assumed if we had considered a surge tank of the Johnson differential type. The riser pipe of that type of tank provides a small amount of water for the first instant of drawdown on the tank, thus making the head drop more gradual and to that extent improving the speed regulation obtained for the turbine units.

*This is the third and last part of the article. Part I appeared in the April 15, 1928, issue and Part II in the May 15, 1928, issue.

Sudden action of the restricted orifice tank must, therefore, receive some consideration if the head drop for commercial load changes is more than say 15 per cent. It should be further remembered that each condition of pipe line, surge tank and resulting speed regulation is more or less a law unto itself and is almost entirely governed by the class of load being handled by the turbine units. What would pass unquestioned in the case of a mining or railway load would be entirely excessive and unsuitable for a paper machine load, where a paper break might mean a loss of many dollars.

Size of Orifice Should Be Such as to Make Total Drawdown Equal to Initial Drop

Regarding the relation of the size of orifice, whether such orifice be the port of a differential tank or the restricted orifice of our present example, it has been found advisable to use such values that the total ultimate drawdown will be approximately equal to the initial drop of the orifice action. In our case, the orifice head was assumed as 15-ft. head drop and the ultimate drawdown in tank level, excluding friction, was 14.60 ft.

For load-off conditions, the greatest duty on the tank will be when the full load might kick off. If the tank is to be non-spilling, it must be built high enough to take all the water so rejected. The conditions are the reverse of the load-on condition and are correspondingly computed. Thus, 500 c.f.s. thrown off in our case would mean 15-ft. retarding head, practically constant, on the pipe line while the water was being gradually reduced to zero velocity. Some latitude in figuring the velocity change is allowable in the case of load thrown off to zero, as the friction load water quantity may mean as much as 30 per cent of the full load water quantity in the case of high speed turbine wheels under low heads, depending on whether or not the gates of the turbine are assumed actually to slam shut or whether the turbine will stay on the line and just float on it, at synchronous speed.

Surge tanks of the so-called simple type, therefore, may be considerably improved by arranging either a restricted orifice or the riser pipe of the Johnson differential tank. There is a practice, still more or less current, of putting in so-called "risers" in pipe line profiles, with the idea that they subdue pressure changes. In the writer's opinion, such alleged damping devices are to be severely condemned, as they are fine for promoting geyser action, if that end helps speed regulation any. When such risers are made of about the same diameter as the pipe line itself, they tend to make the pressure more unsteady than if left out.

Surge tanks in cold climates must be heated to prevent freezing of the surface water. In such climates, when the water in the tank is not in fairly constant motion a thick crust soon forms. One such case with which the writer is acquainted had a restricted orifice smaller than it should have had. Add to this a 6-in. coat of ice at the water level and stir well with a full load kick off! In the classic language of Bert Green, it was like the experience of the guy who unbuttoned the top off a bottle of near-beer his mother-in-law had sent him for his birthday—it blew out four windows in the parlor.

In the case of the water turbine plant in question, it blew up ten sections of old steel pipe in the penstock near the plant and the resulting sudden head drop on the flow line above the surge tank, which was of wood stave construction and 7500 ft. long, collapsed some 500 ft. of it and provided firewood for some time to come. It wasn't convenient for all this to happen at any time of the year and it was still more inconvenient to have it happen in the dead of winter, plunging a couple of towns into darkness in a place where they get coal by long haul.

Practical Considerations Modify Theoretical Design

If your plant is a storage project, see that you allow enough tank height for the lowest expected drawdown on the pond and add to that the drawdown due to load thrown on. The same applies to load thrown off to zero when the headwater is at its maximum height.

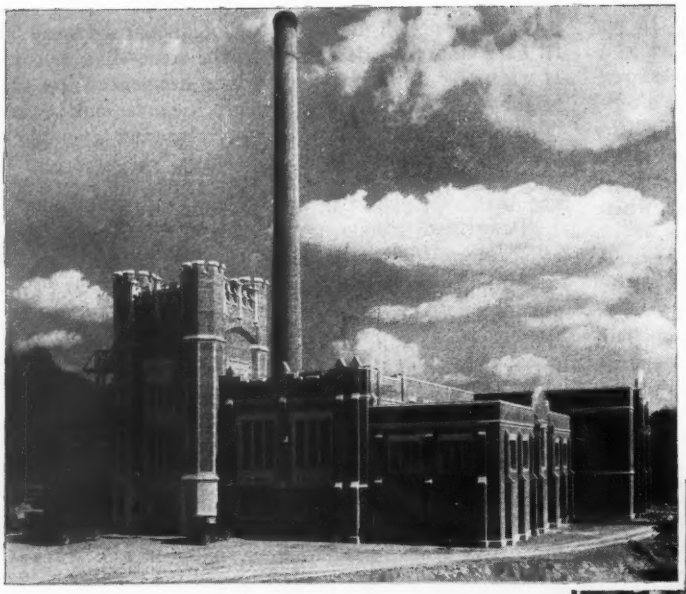
As for the discharge coefficient of the orifice in either a restricted orifice type or a Johnson type of tank, it is better to leave some margin in tank height than to design right down to theory. The discharge coefficient varies somewhat with the head on the orifice and, unless you have data from tests (which is more or less unlikely), a little extra margin may save a great deal of later trouble. The writer recalls a case where some farmers woke up one morning and found their cattle swimming around, all because some goof didn't allow a few more feet on top of a sizable surge tank than the theory called for. Sudden, cold awakenings like those are not conducive to calm dispositions and the lawyers add that intangible item of "personal anguish" to the list of damages. All this means that a great deal of care must be given to the design and construction of surge tanks and that the maximum condition to be expected is in all cases the criterion for the design.

Plans have been announced by W. S. Barstow & Co., Inc., for a new all-1200-lb. station to be built for The New Jersey Power and Light Company at Holland, N. J. The initial installation will consist of a 55,000-kw. turbine generating unit of the cross compound type, comprising a high and low pressure turbine with boiler reheat between them. The high pressure machine will run at 3600 r.p.m., and will operate directly from the 1200 lb., 725 deg. F. mains. It will discharge into a cross over line which returns the steam to the boiler for reheating to 750 deg. F. From the reheater the steam will be returned to the turbine room and will flow through the low pressure unit which will be designed for 1800 r.p.m. and will exhaust against a back pressure of 1 in. absolute.

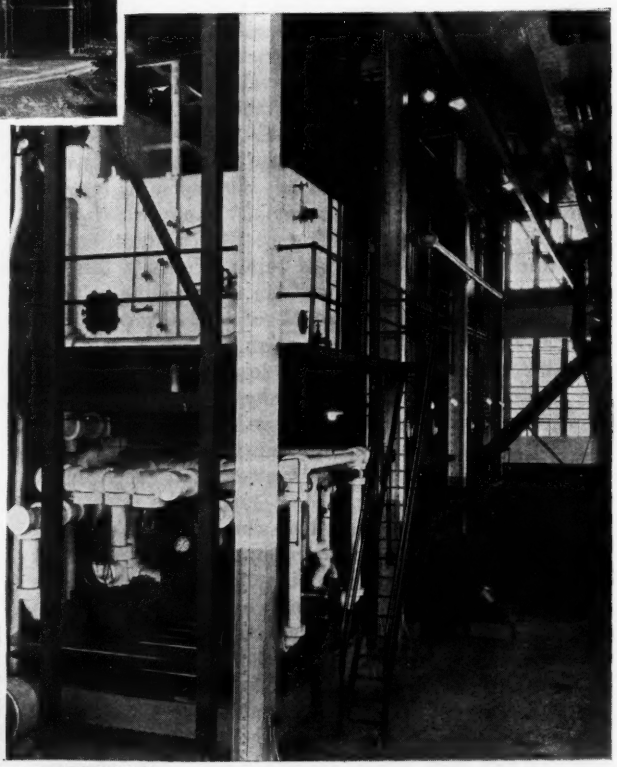
Steam will be admitted to the high pressure turbine through five automatically operated valves, an arrangement designed to give high efficiency at partial loads. Extraction will be carried out from the cross-over line and from three other stages, for feed water heating. A reducing valve will be provided in the 1200 lb. main so that the low pressure unit may be operated independently of the high pressure unit.

This station will be the second in the world to be designed entirely for high pressure steam generation. The Deepwater Station, the pioneer all high pressure station, was announced a few months ago. In both stations General Electric turbine generating units will be installed.

Bleeder Turbines at Knoxville Pumping Plant Drive Pumps and Generators in Tandem

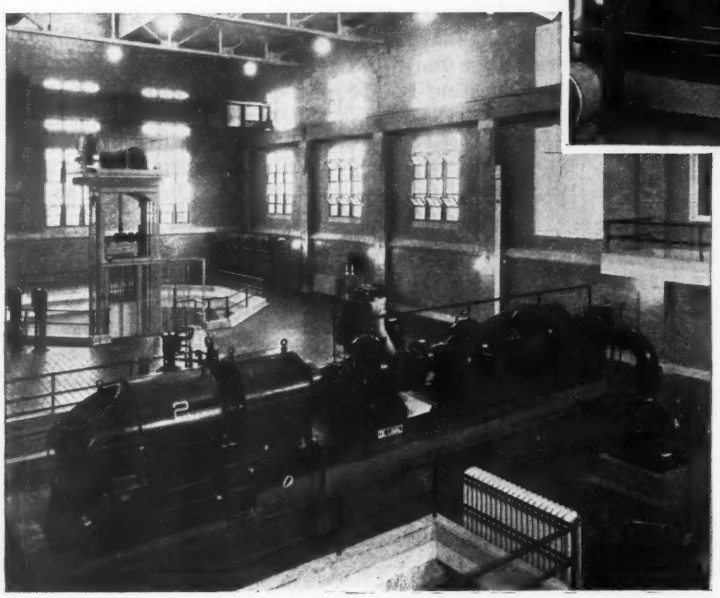


Above—Exterior of new pumping plant at Knoxville, Tenn., which has a total pumping capacity of 30 m.g.d. It was designed by Alvord, Burdick & Howson; Frederick W. Albert is engineer in charge of the City Water Works at Knoxville.



Right—Two 501-hp. bent-tube boilers with superheaters, fired by 4-retort underfeed stokers, generate steam at 300 lb. gage, 200 deg. superheat. Feed pumps and heater in foreground.

Below—View of pump room, showing high-lift pumping unit No. 2. In pit, which is served by elevator, are two 18-m.g.d., 55-ft. head, d.c.-motor-driven, low-lift centrifugal pumps.



Left—Two 15-m.g.d., 350-ft. head, high-lift units are installed. On each unit, a 1560-hp. steam turbine drives through a gear two centrifugal pumps in tandem, a 300-kw., 250-v., d.c. generator and the main circulating pump for a 2400-sq. ft. condenser for the turbine. Standby condensate pump driven by water turbine. Main turbine arranged to bleed 500 lb. of steam an hour at 28 lb. gage for station heating and feedwater heating.

Wash water pump is a 4-m.g.d. centrifugal unit operating against 70-ft. head and driven by a 75-hp., 230-v., d.c. motor. Auxiliary 50-kw. d.c. generator is provided driven by 3000-r.p.m. steam turbine.

Refrigerating Trouble with Lard Roll in Packing Plant

By C. E. Anderson

IN A PACKING HOUSE a brine-cooled lard roll, which is used for cooling and hardening lard, recently began to lose capacity steadily until its capacity became so low that it could not be used. The lard produced was oily and sloppy instead of firm and of good texture. The inlet and outlet temperature of the brine was taken, which showed inlet 0 deg. and outlet about plus 2 deg. This meant a very small temperature difference. It should have been greater—about 6 deg. is a good temperature difference.

With a 6-deg. rise in temperature between inlet and outlet, it is certain that there is a good heat transfer between the hot lard on the outside of the roll and the cold brine inside.

By opening a flange, the brine outlet connection from the roll to the brine tank or brine cooler was examined,

DIAGRAM OF LARD ROLL SHOWING BRINE INLET AND OUTLET CONNECTIONS

and we found the flow of brine free and all that could be desired. This line was opened to make sure that the thermometers were correct, as a restricted flow of brine through the roll would manifest itself by raising the outlet temperature of the brine from the roll above the normal operating point.

We questioned the operator of the roll regarding operation—whether or not anything unusual had happened—but all the information he could give us was that the roll had been losing steadily for a week and the only thing he had done was to tighten up the stuffing box on the outlet pipe of the roll. This had been leaking and he was compelled to tighten this gland a little bit every day.

As the stuffing-box was leaking a little at this time, I tightened up the gland and at once I noticed a slight movement of the outlet pipe. It tightened up or screwed up in the tee, about ⅛ in. or so, as indicated in the sketch.

This furnished me a clue. The friction of the packing, when tightened, was sufficient to turn the outlet pipe a slight amount every time the gland was tightened.

Referring to the sketch, it will be noted that the outlet pipe of the roll extends inside the roll several inches where it is fitted with an elbow, which in turn has a pipe screwed into it, which is nearly long enough to reach the top inside surface of the roll. The normal position of this inside pipe is vertical, thus insuring that the roll is full of brine before it can overflow or run out of the outlet line.

It became quite evident that the trouble with loss of capacity lay right here. The outlet line had screwed up into the tee, due to tight packing, until its position had been changed from the vertical to horizontal or nearly so.

Upon opening the manhole on this end of the roll, we found that our deductions were correct. The vertical pipe had turned so that it was nearly facing straight down.

With the pipe in this position, the roll was operating only about half full of brine and of course it could only cool or extract about half of the heat of the lard.

To prevent a recurence of this condition, the line was screwed into the tee about ½ turn so that the inside pipe was placed in a perpendicular position and then a hole was drilled through the tee and pipe and a pin inserted to prevent the pipe from turning.

This ended capacity troubles with the lard roll. Hardening of the packing in the roll packing boxes was overcome by changing the packing to a very soft square braided flax, keeping it well lubricated by means of a grease cup.

World Engineering Congress

MECHANICAL engineering, its progress and problems, is scheduled to play an important part at the World Engineering Congress opening at Tokio in 1929, which it is expected that a large delegation of American industrial engineers will attend.

On the technical program of the international meeting, which Dr. Elmer A. Sperry, chairman of the American Committee arranging for participation of American engineers, has received from Baron K. Furuichi, president of the Congress, are listed for discussion subjects of scientific and industrial interest covering in scope virtually every phase of engineering activity and development.

For mechanical engineers, papers will include investigations of heat engines and boilers, hydraulic machinery, pneumatic machinery, machine tools and machines for manufacturing, machines for conveyance, ordnance, mechanism and machine design, heating and ventilation and numerous other subjects which cannot be classified under the foregoing heads.

Dr. Sperry, whose precision instruments are well known and widely used in Japan, states that those who attend the Congress will have excellent opportunities to inspect the great industrial centers of Japan and the progress which the island Empire has made along mechanical engineering lines. More than 20,000 enrolled engineers are in Japan, a large proportion of whom are mechanical engineers.

The World Engineering Congress will officially open on October 29, 1929, and extend through the month of November. A number of inspection trips throughout Japan and southern Manchuria have been planned for those who wish to go.

Included in the American technical program committee, of which Professor Dugald C. Jackson is chairman, are H. Foster Bain, Alex Dow, W. F. Durand, J. R. Freeman, Bancroft Gherardi, Allen Hazen, George W. Fuller, F. L. Hutchinson, Edgar Jadwin, A. E. Kennelly, D. S. Kimball, A. D. Little, F. R. Low, Michael I. Pupin, George T. Seabury, George Otis Smith, W. E. Wickenden and O. C. Merrill.

Westinghouse Engineers to Study Lightning

IN AN EFFORT TO uncover more of the mysteries that underly lightning phenomena, a group of electrical engineers of the Westinghouse Electric and Mfg. Co. will establish a laboratory at Chota, Tenn., and will observe, record and analyze lightning phenomena in the vicinity of Chilhowee Mountain. This is a peculiarly suitable location since, during the summer, it has an average of 20 thunder storms a month.

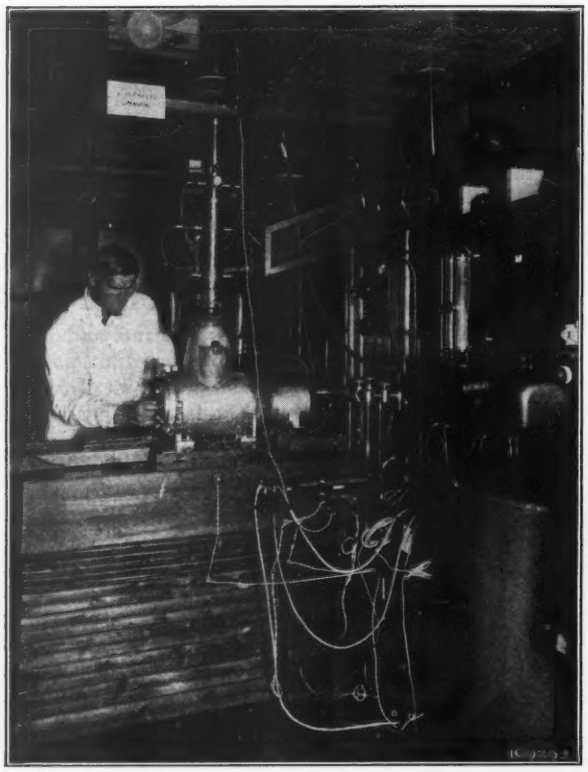


FIG. 1. DR. HARALD NORINDER, FORMER HEAD OF THE RESEARCH BUREAU OF THE ROYAL BOARD OF WATERFALLS, SWEDEN, SHOWN IN HIS PRIVATE LABORATORY

Instruments used in this study will be of the most improved type and will include, Norinder oscillographs, Osisos, klydonographs and cameras. The equipment is to be installed on the power lines of the Aluminum Company of America.

Of great interest to those familiar with lightning studies will be the installation of the Norinder oscillographs. These are extremely rapid and sensitive oscillographs capable of recording surges of as short as a ten-millionth of a second.

Dr. Harald Norinder, Westinghouse consulting engineer and inventor of the apparatus, ranks as one of the foremost authorities on lightning. This distinction is the result of eight years' study in Sweden as engineer and head of the Research Bureau of the Royal Board of Waterfalls in Stockholm. Last spring, he personally brought his oscillograph to Westinghouse headquarters in East Pittsburgh, Pa., to demonstrate its abilities. Impressed by its remarkable performance characteristics, arrangements were made to make the apparatus available for American engineering work.

Equipment will be installed on either side of the highest peak of the Chilhowee Mountains. A Norinder oscillograph will be located on either side of the mountain peak with two klydonographs installed one-half mile from either side of each oscillograph.

The oscillograph operates automatically. Installed on the power line, it gives an exact record of any sort of lightning flash from the smallest spark to a 100 million-volt flash a half mile long. It measures the rate

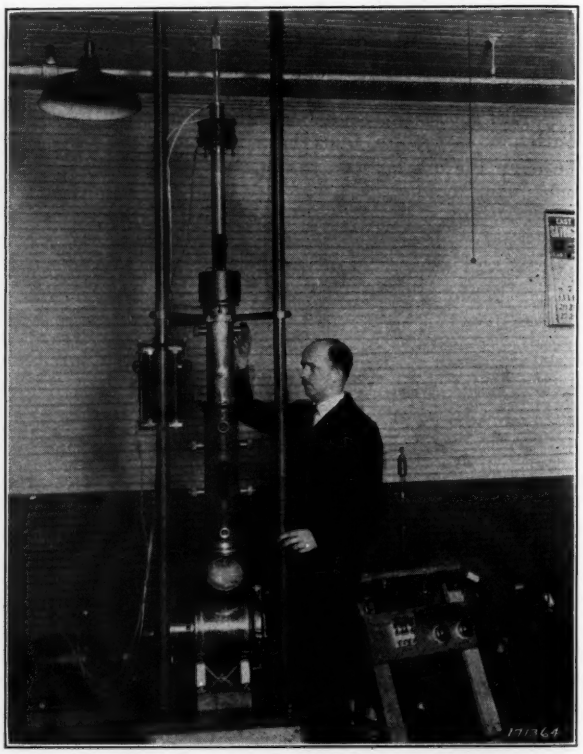


FIG. 2. THE NORINDER OSCILLOGRAPH, A REMARKABLE INSTRUMENT FOR THE STUDY OF EXTREMELY RAPID ELECTRICAL OSCILLATIONS

of rise of the voltage surge, the maximum voltage attained, the duration of the charge and the rate of decrease. It is essentially a cathode ray oscillograph in which the cathode ray is deflected by electrostatic or magnetic fields. The entire apparatus is in a vacuum.

Klydonographs will record the maximum shock received by the transmission line and thus supplement the oscillograph records. Osisos will function as a part of distance finders to tell the operators how far distant from the power line the bolt of lightning flashed. The cameras will record any lightning within their range.

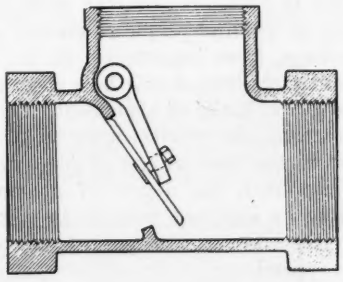
All the devices are automatic. For example, oncoming thunderstorms will automatically give warning of their approach, by ringing a bell.

With this installation and with a crew of engineers on duty 24 hr. each day for an indefinite period, it is expected that data concerning the effect of lightning on high-voltage transmission lines will be recorded in such detail that the development of lightning-proof apparatus will be greatly facilitated.

Jammed Check Valve Causes Pumping Trouble

AT TIMES, we have brought to our attention the fact that the modern plant and the plant of some years ago are two distinct propositions. The whole system from stem to stern, as it were, has undergone extreme changes.

In the old plant where piston or plunger pumps were employed, it was necessary to provide relief valves in case of a closed discharge. I have seen the top of a



SWING CHECK VALVE JAMS DUE TO LOST MOTION

pump badly damaged where a relief valve was not provided and the discharge had become closed. This pump was a horizontal piston type, gear driven; with the centrifugal pump, a different condition prevails.

Speed is an important factor in centrifugal pump operation. Where three, four or five stages are employed, if the water cannot get out it stays in and revolves with the rotor or impellor and causes trouble. After the water has looped the loop a few thousand times, it gets hotter and hotter until it generates steam. A cold water pump that is allowed to operate with a closed discharge may reach a point at which the casing may crack from expansion.

Considerable trouble was experienced in a modern turbine plant by the failure of the centrifugal condensate pump on a turbine condenser unit. The water would rise in the glass, the injection would have to be closed and the load dropped to about one-third of rating. A tachometer showed the condensate pump to be up to speed and an inspection showed the pump to be in the pink of condition yet the condensate could not be removed quickly enough.

Some smart man in the group suggested looking at the discharge check valve. As the cover was removed and the clapper lifted and dropped several times, it was evident that the check was working properly. When this machine was put on the line again, no trouble was experienced and a full load was carried very easily. After a couple of weeks, trouble was encountered again, so the cover of the check valve was removed and the clapper lifted and dropped a few times as before. Upon starting, everything was working properly again.

This process of removal of check valve cover was repeated at least six times before the cause of the trouble was located. The sketch shows how the clapper caught in the seat hole, and only allowed a small portion of the water to be discharged. By making a thick washer and drawing the clapper tighter to the arm, no further trouble was noted.

Had the condenser and pump been of old types, the check valve would have opened or the "roof would have lifted." Incidentally, more trouble is found with check valves on pump installations than with the pump and almost always the discharge check is first to be looked at when trouble develops.

Even though the centrifugal pump has no pronounced pulsation, there appears to be a high speed vibration, caused no doubt by the rapidity with which the rotor partition cuts the stream of water which causes the check valve to be under a constant flutter and hence wear takes place.

New York City. JOE BROWN.

Location of Steam Jets Affects Operation of Furnace

ERECTION of a horizontal return tubular boiler in a mountain valley was delayed by non-arrival of the necessary fire bricks and the furnace was lined with rejected paving bricks, rejection having been solely because of chipped corners. The paving brick furnace lining lasted, with little burning off, flaking or spalling, for more than a year, when it was found necessary to force the boiler beyond its nominal rating in order to handle additional work in the factory.

Accordingly, four ½-in. steam nozzles were placed in holes drilled through the boiler front and steam was turned on until the required steam production was obtained but with the result that in a few months, the paving bricks were burned or spalled away and the boiler showed signs of failure at the seams, sheet-ends and tubes. New lining, also of paving bricks, was placed in the furnace but the steam jets were removed and each of the four placed inside of 6-in. air pipes which were cut through the brick boiler setting into the ashpit, two on each side of the boiler.

On each side of the furnace the air pipes were branched out of an 8½-in. air pipe, in which a tight-fitting damper for the control of the air blast was placed. It was intended, as soon as they could be procured, to connect the air pipes to a pair of fans,

whereby the required amount of air could be driven into the ashpit without the use of steam jets.

This arrangement worked fairly well and neither the boiler furnace nor shell were thereafter appreciably damaged by the forced fire. The engineer, however, began to "look sidewise" at the forcing of moisture into the boiler furnace with the air, so he placed steam jets of equal area in the up-take of the boiler and found that by means of this arrangement he burned even less coal than he had before.

Indianapolis, Ind. JAMES F. HOBART.

Does the Public Really Want Smoke Eliminated?

HAVING RECENTLY served on a Smoke Elimination Committee in one of our largest cities, I was interested in your editorial "Does the Public Really Want Smoke Eliminated," published in the May 15 issue.

There is no question that the public is interested in the elimination of smoke but the real question is: Does it realize the cost and is it ready to foot the bill? Few engineers realize that the most difficult problem in connection with smoke abatement is not that of drawing up ordinances and formulating rules for operation and installation of adequate equipment but that of enforcement and, other things being equal, the question of enforcement resolves itself into a question of finance.

One or two fundamental facts must be kept in mind. It is questionable whether the common law will permit the enforcement of any statute, law or ordinance, which calls for the elimination of all smoke. It is generally held that the smoke must be at least reasonably dense and satisfactory evidence of its density must be produced in court.

At the present time, the only practical standard of smoke density is the Ringelmann chart, which is admittedly inadequate and is open to the great objection that the readings are to a large extent a matter of personal judgment. This fact greatly reduces its value as legal evidence, although in the case of reasonably dense smoke it is generally found to be sufficient. The fact that the available standard is one which indicates color only and that the color indications are modified by the brightness of the sky and surrounding conditions, leaves us with practically no means of ascertaining the real degree of air pollution caused by a chimney.

Cases will sometimes be found in which only complete modification of the boiler installation will make it possible to operate smokelessly and such modification may be beyond the means of the owners, while shutting down the plant would cause severe hardship to many.

If we insist upon treating the problem as if it were simply a matter of the elimination of smoke, we must not lose sight of the fact that at present it is practically impossible legally to define smoke except in terms of color, whereas the basic question is that of air contamination in whatever form it may present.

Sources of air contamination are increasing daily. It is quite possible that, from a purely medical point of view, smoke, as we understand it, may be among the least harmful of these sources. If this should be true to any extent, it is important that we should deal with the subject broadly and not permit the more spectacular indications of smoke to camouflage the real conditions.

Economic loss caused by smoke is undoubtedly great, more, perhaps, on account of the damage to buildings and materials than through loss of combustion efficiency, as of course all engineers know that a smokeless chimney does not necessarily indicate efficient operation. There is no doubt that a smoky atmosphere has a depressing effect upon individuals and often lowers their efficiency but the detriment to health is possibly often over-rated, as it has been found that noticeably smoky cities are sometimes comparatively healthy. At the same time, nobody will question the desirability of a clear sky.

Two sources of air pollution at the present time are automobile exhaust gas and pulverized coal ash. In large cities, the first is perhaps a more serious menace to health than smoke. The effect of breathing air charged with minute particles of ash which has been discharged from chimneys in a practically invisible form should be made the subject of a thorough investigation.

In the writer's opinion, a serious effort should be made to arouse the public to a sense of the dangers of air pollution in general; in doing this, we should be careful not to overemphasize the question of smoke in such a way as to blind people to sources of pollution that are, perhaps, more important. At the same time, it is important that there should be a clear understanding of the practical limits of abatement.

To be practical, the problem must be treated as one of abatement rather than as one of elimination and, as previously suggested, the degree of abatement which can reasonably be expected may be to a great extent measured by the amount of money which the taxpayers are willing to spend.

Newark, N. J. JAMES O. G. GIBBONS.

Engine Adjustments Must Be Maintained

WHEN DISMANTLING part of an engine, for any reason, care should be taken to mark parts properly if they are not already so marked and so to observe original position of parts that they may be returned precisely to these original positions after inspection, repair or other manipulation.

After long satisfactory service a certain four-cylinder, 200-hp. Diesel of the trunk piston type started to give trouble with the cylinder lubrication, in one instance failing so badly that the piston pin bearings seized. There was also trouble with the exhaust valves burning out after the engine had been carrying a heavy load. It was noted, however, that if the compression in any cylinder was defective, that cylinder was free from lubrication and valve burning troubles.

Indicator cards were taken and showed a maximum compression pressure of 480 to 490 lb. per sq. in. The clearance in each cylinder was then tested by placing a small lump of lead on top of each piston, replacing the cylinder head and barring the engine over until each piston had been over the compression stroke. The cylinder head was then removed and the pieces of lead taken out and measured with a micrometer, three thousandths of an inch being allowed for the expansion of the lead when the compression was released. The mechanical clearances obtained from each cylinder

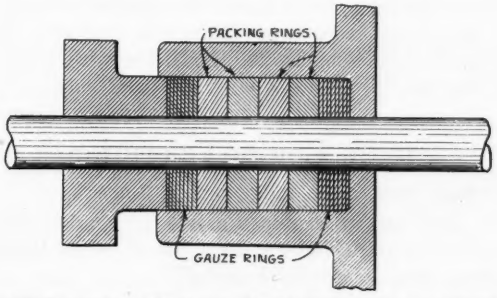
were then compared with those given by the manufacturers, and were found to have been decreased by as much as 1/100 to 1/64 in. The clearances were corrected by adjustments at the big ends of the connecting rods, after which the lubrication and valve burning troubles were found to have been overcome. It appears that the clearances had been altered when the big and small ends of the connecting rods had been adjusted, as this had evidently been carelessly done. The increased compression due to the reduced clearance had raised the compression temperature and this caused the trouble mentioned.

Brentford, England. W. E. WARNER.

Packing a Worn Piston Rod

GREATEST WEAR on a piston or long travel valve rod is usually found at mid-travel. If the packing is drawn up tight enough to keep the box from leaking on such a worn rod, it is more than likely the rod will become heated and destroy the packing, thus causing rapid wear on the already worn rod. The capacity of the stuffing box that I saw was five rings of packing.

To overcome this difficulty, a lot of circular pieces were cut from some old brass wire gauze, or fine screen,



GAUZE RINGS PROVIDE FLEXIBILITY IN PACKING

and placed in the bottom of the packing box, a cut being made on each piece to allow setting on the rod. Then three rings of regular packing were installed and more of the wire gauze washers placed on top. After the gauze rings had become fairly closely set in the box, only slight tension is required since the packing seems to give best service when left to expand and contract.

Hollyburn, British Columbia. JAMES E. NOBLE.

Non-Condensing Operation Needs No Valve Setting Change

CORRESPONDENT J. B.'s questions on "Steam Engine Operation", page 694 in the June 15 issue and the answers which follow, interest me, particularly No. 7 relative to the change in valve adjustment.

Now, I am aware of the fact that it is considered necessary to change the degree of compression in steam engine cylinders when changing from non-condensing to condensing operation and probably theoretical considerations confirm the idea and justify such changes; however, I am of the opinion that it is not absolutely necessary to make any change in the compression feature, provided the correct degree has been given at first. The following is an actual personal experience in relation to the matter.

Some years ago, I had charge of a 10,000-hp. city railway power station in Brooklyn, N. Y. (the old 3rd Ave. station at 1st St., located on the banks of the Gowanus Canal), in which, among other units, were two Allis-Chalmers cross-compound Corliss condensing engines of 1500 hp. each, which exhausted into separate jet condensers. The condensing water was obtained from the canal through two 10-in. suction lines which were deeply buried underground, from the station to the canal, a distance of about 200 ft.

Due to settling and possibly to faulty layout at the time of the installation, further assisted by the corrosive action of the water from the canal, which was at that time heavily charged with acids from the several factories which discharged industrial waste into the canal, the suction pipes began to leak, so it was difficult to secure sufficient water to maintain even a 22-in. vacuum in the condensers at high tide. During periods of low tide, we could not run the engines condensing at all, so we exhausted from the low-pressure cylinders direct into the atmosphere through an atmospheric relief valve.

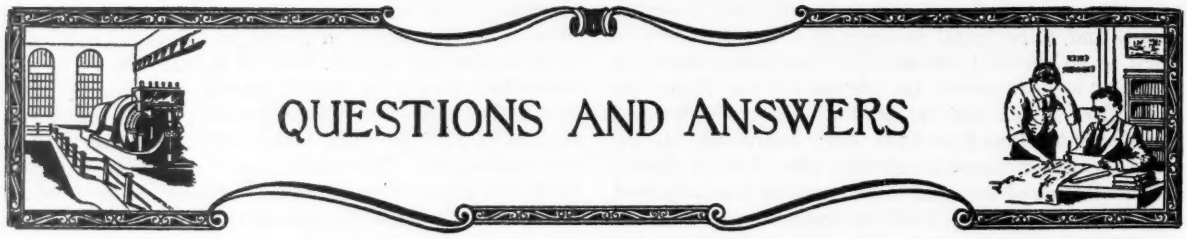
At the time of installation, doubtless everything was in proper condition with these engines and they ran condensing at all times; therefore the valve adjustments for steam distribution throughout the engines were made to suit condensing requirements and were presumed to be correct. At the time of which I write, however, we were obliged to run those engines non-condensing for a considerable portion of the day and when we did, the comparatively high compression in the low-pressure cylinders caused the steam valves in those cylinders to lift from their seats at the beginning of the stroke of the pistons and slam down again on their seats when the receiver pressure exceeded the pressure in the cylinders.

Indicator cards were taken from both cylinders of the two engines, under condensing and non-condensing conditions, and plainly showed that the relatively high compression pressure in the low-pressure cylinders caused the valves to slam. The steam consumption of the engines during non-condensing periods also was excessive and severely taxed the boilers.

So we readjusted all the valves on one engine and reduced the compression materially in both high and low-pressure cylinders and again took a set of indicator cards which showed considerable improvement in the steam distribution for both condensing and non-condensing operation. The results obtained by changing the valves and therefore the steam distribution were cessation of the slamming of the valves while running non-condensing, reduced steam consumption under the same load and quiet running under both condensing and non-condensing conditions.

Results were so gratifying that we not only changed the valve adjustments on the other engine, but we reduced the compression on all the engines through the entire plant and in an exceedingly short time the saving in fuel consumed was decidedly noticeable. In that particular case, it was clearly proved that the valves of steam engines could be so set as to give a steam distribution that would be equally suitable for condensing or non-condensing operation, both with regard to quiet running and economy in the use of steam.

Brooklyn, N. Y. CHARLES G. MASON.



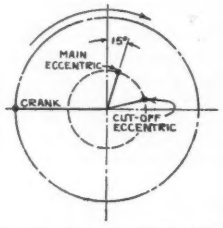
QUESTIONS AND ANSWERS

Meyer Valve Gear Setting

PLEASE SEND me the correct method of setting the Meyer cutoff valves on an Ingersoll-Sergeant air compressor. H. B. T.

A. Eccentric and shaft are marked so as to permit bringing them into their original correct relation as set by the builder. In resetting, it is necessary first to bring these marks together and then to screw up on the set screws which fasten the eccentric. After this has been done, the following instructions, when fully complied with, will enable any engineer to reset the valves.

Set the eccentric which actuates the lower valve so that the angle of advance is about 15 deg., thus: Put the crank on either dead center and set the main valve at that end so that it has about 1/64 in. lead and set the nuts temporarily against the valve; now turn the



RELATION BETWEEN MAIN AND CUTOFF ECCENTRICS IN MEYER VALVE GEAR

wheels to the other dead center and see how far the port edge of the valve is from the edge of the port. Equalize the leads at the two ends of the stroke by dividing the difference between these two measurements between them. When this distance has been exactly divided, the nuts should be jammed up tight until they bear against the valve, in which case the valve stem will be set at correct length.

Having the crank at dead center, the eccentric should be moved so that the valve has 1/64 in. lead; the eccentric should then be fastened. The wheels should then be turned to the opposite dead center to check the amount of lead. If the leads are not the same they should be averaged as closely as possible.

Different positions of the stroke are laid off along the crosshead slide in reference to each end of the stroke; the cutoff valves are screwed together on the rod and, with the crosshead set at any desired part of the stroke, the cutoff valve is moved by means of the hand-wheel until it just cuts off the port on the main valve. The crosshead is then moved to a corresponding position at the other end of the stroke, when the other cutoff valve should just close the port on the main valve. If it does not do this, the valve stem should be lengthened or shortened in the eye-piece or one cutoff valve can be put on the stem a thread or two sooner than the other, thus equalizing them for both ends of the stroke.

There is only one position where they will cut off exactly the same on both ends and if varied from this, the cutoff will be different on both ends of the stroke, being greater relatively on one side if increasing the cutoff and less relatively on the same side when diminishing the cutoff. In this manner, the cutoff valves may be arranged to close correctly at one-half or any other fixed part of the stroke while, at one-fourth cutoff, one valve will be a little ahead of the other and, at three-fourths cutoff, the opposite end will be ahead. The best that can be done with this type of valve is to obtain one correct point of cutoff while at all other points it will not be exactly correct.

Accompanying sketch shows the relation between the main and cutoff eccentrics. The arrow shows the direction of rotation when standing in line with the shaft with the air cylinder at your right-hand side.

Steam Engine Operation

PLEASE answer the following questions:

1. How can an ordinary cross-compound engine be started without prying on the flywheel when the high pressure crank is on dead center?
2. When you have a vacuum of 11 lb. on your gage, what does this mean with regard to the operation of the engine?
3. How may the steam valves on a Corliss engine be tested for leakage?
4. How can the loss due to high clearance in a cylinder be modified?
5. Why are detachable valve gears not used on high speed engines?
6. How would you measure the steam lap?
7. Give two reasons why dashpots are used on Corliss engines?
8. What do you understand by the term "positive cutoff"?
9. What are the "striking points"? How would you obtain them? What is their value?
10. If the admission line on an indicator diagram taken from a D-slide valve engine inclines inward from perpendicular, what defect in the valve setting is indicated? A. L.

A. A cross-compound engine may be started without prying on the flywheel even when the high-pressure crank is at dead center by opening the exhaust valve on that cylinder, thus permitting steam to go over to the low-pressure cylinder through the receiver.

2. If you have a vacuum in the cylinder, it would indicate that it was operating condensing.

3. Steam valves on a Corliss engine may be tested

for tightness by taking off the bonnet on the valve and admitting steam into the cylinder through the opposite steam valve.

4. Plates may be attached to the cylinder head to reduce excessive clearance.

5. Detachable valve gears are limited in their speed of operation because of inability to pick up the die on the valve arm at excessive speeds.

6. Steam lap may be measured by taking off the valve box cover or bonnet, as the case may be, and using a scale.

7. Dashpots are used on Corliss engines to cause quick action at cutoff and to cushion that action.

8. By "positive cutoff" is meant one which is accomplished by direct mechanical connection such as employed on a four-valve engine.

9. "Striking points" are employed to show how much mechanical clearance there is at any position of piston. The striking point at one end is obtained by disconnecting the connecting rod and forcing the piston to that end until it strikes the cylinder head, then marking the guide to correspond to a mark previously made on the crosshead.

10. If the admission line on a diagram inclines inwardly, it shows that there is not enough lead; admission has been too late.

Boiler Operation and Construction

PLEASE let me have the answers to the following questions:

1. How should an injector be piped up so that you can vary the amount of water it will put into the boiler?

2. What is the maximum pressure allowed on a boiler with lap joints according to the Ohio State standard rules?

3. Why are welded joints not more generally used on boilers?

4. How can you tell when "fire cracks" are dangerous?

5. If your pop safety valve does not stay open until the pressure is reduced but keeps popping at short intervals, what can be done to remedy the trouble?

6. If you find the segments between tubes in the rear tube-sheet to be bulging outwards slightly, what probably has caused this and what should be done to remedy it?

7. What might cause a spring safety valve to "rumble" on its seat and how can this be remedied?

A. L.

A. No change is necessary in the piping; the amount of water delivered by the injector may be regulated by opening or closing the valve in the steam pipe until the required rate is attained.

2. Ohio rules allow 100 lb. pressure in sizes up to 36 in. diameter and 15 lb. in sizes over 36 in. diameter.

3. Autogenously welded joints are now quite generally used for low-pressure boilers limited to 15 lb. press. Forge welded joints have always been used in corrugated furnace construction and, to a limited extent, in boiler shells. Where welded joints are used, it is customary to allow a working pressure of only about 63 per cent of what would be allowed for riveted joints, hence there is an increase in cost where welding is employed due to increased weight of plate for a given pressure.

4. Fire cracks are not dangerous until they leak and even then they are annoying rather than dangerous since they cause the fire to go out. When leakage occurs, however, corrosion is likely to occur and destruction to follow.

5. If the pop safety valve "flutters", adjust the blow-back ring. If this ring is screwed down too much, the valve is too sensitive.

6. If the segments between the tubes in the rear tube-sheet bulge outward, it is likely that the tube-sheet was not flat originally. If the tubes are sound in a bulged tube-sheet, it is best not to attempt to flatten the tube-sheet, as harm will result. If the tubes should be renewed, the tube-sheet may be flattened after removal of tubes by proper manipulation with hammer and suitable backing to strike against.

7. Rumbling may be remedied by adjustment of the blow-back ring.

Drum Plate Efficiency Lowered by Tube Holes

KINDLY let me know the efficiency of plate in tube section and what pressure the drum, constructed as shown in the sketch, can stand? J. B. H.

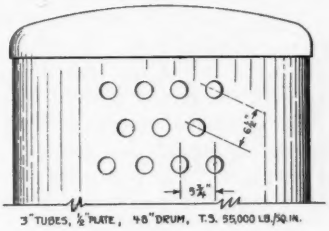


DIAGRAM OF BOILER DRUM

A. It is necessary first to find the longitudinal pitch which, since it was not given, may be obtained from the two pitches given as follows:

$$(6.5)^2 = (5.75 \div 2)^2 + (P \div 2)^2$$

where P = longitudinal pitch, therefore

$$\sqrt{P \div 2} = \sqrt{(6.5)^2 - (5.75 \div 2)^2}$$

$$P \div 2 = 5.8$$

$$P = 11.6$$

The efficiency of the plate in the tube section will be $(P - d) \div P$ where d = diameter of the hole which is usually taken as $\frac{1}{32}$ in. larger than the diameter of the tube. This efficiency for the longitudinal section is, therefore, $(11.6 - 3.03) \div 11.6 = 65$ per cent.

For the diagonal section, the efficiency is $(6.5 - 3.03) \div 6.5 = 53.5$ per cent.

The latter, being the lower, is used in determining the working pressure which is equal to $t \times T \times E \div R \times F$

where t = thickness of plate in inches
T = tensile strength in lb. per sq. in.
E = efficiency of plate
R = radius of drum in inches
F = factor of safety.

Substituting our known values, we have for the allowable working pressure,

$$0.5 \times 55{,}000 \times 0.535 \div 24 \times 5 = 123 \text{ lb.}$$

EDITORIAL COMMENT

It Pays to Know Where the Water Goes

Hydro-electric plants have been running along in their accustomed way for years, not caring much about the amount of water wasted over the dam, through leaky water-wheel gates and in inefficient performance of water-wheels that were worn out or improperly operated. Now, faced with the competition of steam plants that are growing steadily more efficient, together with the increasing costs of hydro-electric development, due to various forms of taxation, and the influence of widespread inter-connections on the whole relation between steam and water-power development, the hydro-electric plant is beginning to discover that it pays to know what is happening to its water.

As expressed by the N. E. L. A. Hydraulic Power Committee in a recent serial report, real additions to earnings are being made by various companies as a result of their water-wheel tests. Expense of these tests and of the continued use of the resulting data is small in comparison with the return derived from added output. Since this additional output is obtained without materially increasing production costs, it has a direct effect on net earnings. The percentage increase of the latter is greater than the percentage increase of plant output.

To secure this increase, it is necessary first of all to consider that the water available is the fuel of the plant in just the same way that coal and oil are fuels of the steam plant. Assuming for the value of the water a definite amount per acre-foot or other convenient quantity, the problem is to secure the greatest output in kilowatt-hours per acre-foot at the lowest cost.

Complete tests of the water-wheels and full records of plant operation are necessary to secure this result. Water-wheels can be calibrated to serve as water meters, wear on units can be measured, points of best efficiency may be determined, most economical loading of units can be worked out. One company uses a form of balance sheet to apply the records to commercial operation. Whatever method is employed, full advantage should be taken of the data obtained.

One operating company increased its production 15,000,000 kw-hr. in 1926 over that in 1925 with the same head and amount of water available, or 1.5 per cent gain, the added output having a value 20 per cent more than the cost of obtaining it. The testing equipment is now paid for and without doubt will enable the operators to make further improvements in performance. Similar results are reported by other companies.

With the exception of certain details of testing equipment, there is nothing new in the idea of finding out what the performance of a hydro-electric plant really is and then acting on that knowledge. It is accepted as axiomatic by the central station steam plant. Yet in the hydro plant it has often been neglected, except for the acceptance tests made on new units. The surprising thing is that the value of routine testing and record keeping should suddenly be realized at this late date by public utility hydro plants. Possibly it is because we are only now beginning to approach the limit of stream and storage development. Whatever the reason, all hydro plants, public utility or industrial, should give it attention.

Capital for the Small Industry

Because of the immensity of many of our industries, there is a tendency for the general public to lose sight of the large and increasing number of small enterprises that form an important factor in our present industrial economy. Despite the almost inevitable pressure of the prestige of the larger industries, due to their widespread geographical distribution and their concern with practically every human desire, at the same time the conviction is gradually spreading that there is no particularly inherent goodness or badness in an industry merely because of its size. This feeling is backed up by a considerable body of evidence, as has been previously pointed out.

Small industries, however, labor under a handicap about which large ones seldom have to worry. This is the handicap of insufficient financing to take care of the normal growth of the business, modernization of processes to keep them up to date and similar factors. This was pointed out recently by a prominent investment banker, after a tour of the country. He states that he found many small corporations, all with small capitalization, which have been able during the last two or three years to go along without piling up inventories and with the finished products rolling out of their factories on order just about as soon as completed. These industries are perfectly sound and are making money. Yet they often justify a certain amount of expansion to obtain the optimum size for their conditions. Such industries, our banker finds, are almost completely overlooked by the financial interests accustomed to big deals and they present a fertile field for some financial organization.

Financing on a small scale like this involves, of course, as much overhead expense to the banker, under present methods of issuing securities, as do large scale operations. That is the problem that the financier must work out. But, if any one ever can solve it, he will find a vast field open before him.

We wonder, however, if our banker who thus analyzes the small industry is thinking solely in terms of the industry, when he sees need of expansion. He has doubtless heard boys told or been told himself about

the danger of "getting too big for his breeches," meaning getting a little swell-headed. And here is precisely a danger that the small industry must watch. For, if a small industry attempts too much expansion, financial dangers arise; also it loses many of the advantages it possessed as a small industry. As previously noted, each industry has a definite size for best efficiency in purchasing, production and distribution. If it has not reached that optimum size and feels the need of $100,000 or $200,000 in additional capital to enable it to do so, that is sound economics. Some method should surely be worked out to enable it to secure such capital as easily as the large organization secures the millions of dollars it needs. But this must be done without disturbing its already sound financial basis and without attempting over expansion.

Off Duty

It is generally conceded by those who know least about it, that this is a scientific age and that humanity has been benefited greatly by the countless blessings of science. The automobile and the radio are pointed to as pre-eminent examples.

Yet, to one who recently had the privilege (or misfortune) of "tuning in" on the recent political conventions and of listening to the silver tongued hokum of the demagogues and kept patriots, the assertion that this is a scientific age becomes clouded with an element of doubt. For science is exact and is based on truth, but if the balderdash aired at political conventions by politicians engaged in the grave and important task of selecting the Nation's chief executive is based on truth, then so is the inane theory that all men are created free and equal.

"Hooray for our side," yells the keynoter, "we are pure and love each other but the Demopublicans are all scoundrels, crooks and thieves—bla bla."

Having thus relieved himself, he goes into panegyrics over the working man or farmer—the poor, downtrodden, son of the soil; exploited by capital and kept in submission by toil. It is difficult to restrain from weeping during this part of the performance—the loud speaker, in fact becomes visibly damp and shows signs of collapsing. But not for long. There is a remedy it appears; all that is necessary to save the noble peasant is to kick the Demopublicans out and put the Repubocrats in office who will at once proceed to enforce the ideals of Hamilson, that noble American, the founder of the party—bla bla. At this point the house shakes with thunderous applause and the loudspeaker regains its customary composure, in fact, it shows signs of blowing to pieces.

The gifted delegates next indulge in a parade around the hall during which time the radio announcer all but goes into hysterics in an ecstatic descriptive orgy.

It is difficult to reconcile these antics of supposedly sane human beings with the customary claim that this is a scientific age. If the performance were nothing more than a show staged to satisfy the childish fancies of the delegates there would be no cause for criticism but the sad part of this story is that the nonsensical descantings of the politicians are often taken seriously. The masses are swayed, not by reason or intelligent thought but by emotion and flattery.

If ours were a scientific civilization, such species as demagogues would not exist. Science has no place for demagogues nor does it seek to conquer by emotion and flattery; science appeals to reason. Our civilization is decidedly unscientific. As stated only recently in an article in the Scientific Monthly by Prof. Meyer of Stanford University, "to regard our civilization as scientific is a slander upon, as well as a tribute to science for our age is no more scientific than it is Christian."

Because we are so familiar with the many products of science, we are prone to believe that we are a scientific thinking people but this is not so. The average person knows nothing of science. He uses his telephone, his automobile and radio, and reads and talks of scientific achievements with amazing nonchalance, but knows practically nothing as to how these various things operate. The products of science are the work of a very small group of people—it is they who are scientifically minded, not those who use the products.

We are not even educated scientifically. A study of the courses taken by students at one of our foremost universities, for example, shows that only about one-tenth of their time was spent on natural science in their entire progress from kindergarten to the end of college life.

It is this disregard for a knowledge of science on the part of modern civilized society that makes it possible for quackery to find such a multitude of patrons among all classes. From the electronic reaction hokum of Dr. Abrams, to food cults and pseudo endocrinology—from gland extracts to floating universities, quackery and pseudo science in all its forms finds an unlimited market throughout the civilized world. Real science is ignored in all but a few fields of human endeavor. Were science really heeded, some of the most perplexing and distressing social problems would have found solution long ago.

But belief and dogma are easier to assimilate than scientific knowledge and it will be a long time before the majority of mankind become scientifically minded. Belief spreads easily and dogma being ready made is always at hand. It is easier to believe what the politicians say than it is to prove them and since proof is not demanded they have at their command an array of facts that, could they be proved, would strike envy to the heart of any scientist.

So, in a world which on every hand makes use of the marvelous products developed by a small group of scientifically minded people, the truly fundamental dictates of science are ignored. Human relations and political science have undergone little progress in the last few hundred years, and until a more intelligent and scientific attitude is exhibited toward these things, little, if any, progress can be expected.

MAN'S POWER PROBLEM is mainly to defeat old Carnot's law of the irreversibility of process; and though man never can defeat it, his steps in that direction have marked the progress of his material affairs. For the energy that comes from all engines available to his use must always be a good deal less than what goes in. His efficiency and that of all his engines is measured by the energy he saves or makes available.—Baker Brownell.

Oil Power Meeting of A.S.M.E.

PENNSYLVANIA STATE COLLEGE, JUNE 14 TO 16

FULL ADVANTAGE was taken by the large number in attendance at this meeting, representing manufacturers, users, public utilities, research and teaching groups, of the interesting technical discussions, the exhibit of engine and accessory parts and of the social facilities provided so generously by the Entertainment committee.

Sessions got under way on Thursday morning with an address of welcome by Dr. Ralph B. Hetzel, president of Pennsylvania State College.

Immediately, technical discussion was taken up, a paper being presented on European Diesel Engine Developments by Oliver F. Allen. The author gave a sketch of the oil situation outside of the United States, illustrating with slides the early historical developments and dealing with the air injection Diesel up to 15,000 b.hp., now in use in some European plants.

Economics Session

Thursday afternoon session was devoted to economics, the first paper being presented by Harlan A. Pratt, manager of the oil engine department of the Ingersoll-Rand Co. He stated that in 1923 output of Diesel engines by the manufacturers of the United States was given by the Bureau of the Census as 198,000 hp., and for 1925, 409,000 hp., the same figure being estimated as production for years 1926 and 1927. The reason that the Diesel engine has taken and will continue to take a large place in industry is because it is the most efficient converter of the latent heat energy of fuel into active mechanical energy, its thermal efficiency being approximately 33 per cent, in horsepowers even as low as 25 to 50. With waste heat from the exhaust utilized, this efficiency may be increased to over 50 per cent.

As an example of the possible savings, Mr. Pratt quoted results from comparison of the performance of an electric tug with installation of two 350-hp. Diesel engines with a tug of the same size steam-operated. The fuel consumption for the Diesel tug was 480 gal. per day and for the steam tug 2314 gal. per day, a ratio of 1 to 4 and a cost saving of $80. In addition, there were some $14 saved daily in the wages of the crew, giving a total yearly saving of over $30,000, with the added convenience of having to refuel once in 15 days instead of every 3 days.

For such uses as shovels and drag line units, the Diesel engine is estimated to replace the gasoline engine with a saving in the operation of 100-hp. engines of approximately $1.50 per hr., based on 20c gasoline and 6c fuel oil.

Central Station Use

Of the prime movers in the country today, about 40 per cent are in central stations and 60 per cent in private plants but central stations are not users of Diesel engines to any extent on account of the sizes of the units. For smaller plants and for reinforcing central station lines, also for carrying peak loads and for standby use in central stations, the Diesel engine has been found desirable and, of the engine horsepower installed in 1926, 17.8 per cent of the Diesel engines were in central stations.

Mr. Pratt gave tables comparing estimated costs and actual costs which are given below. Table A is furnished by a prominent manufacturer of Diesel engines, based on its experience, while Table B is actual results from the operation of a plant. The closeness with which these figures check is noteworthy.

TABLE A—DISTRIBUTION OF POWER COSTS IN A TYPICAL DIESEL ENGINE POWER PLANT

	Total cost	Cost per kw-hr.
Fuel oil	$ 4730	.0050
Lubricating oil	531	.0005
Labor	5000	.0052
Maintenance, 2 per cent	500	.0006
Fixed charges, 11.72 per cent.	3800	.0039
Total	$14,561	.0152
Total—less fixed charges	$10,761	.0113

Plant: Three 120-hp. engines, 240 kilowatts, cost per kilowatt, $135; production, 946,080 kw-hr. per year; load factor, 50 per cent; fuel oil cost, 5c per gal.; lubricating oil cost, 55c per gal.; kw-hr. produced per gallon of fuel oil, 10.

TABLE B—ACTUAL RESULTS OF PLANT INSTALLED

	Total cost	Cost per kw-hr.
Fuel oil	$ 9939	.005640
Lubricating oil	976	.000554
Labor	5246	.002960
Maintenance	1289	.001300
Fixed charges, 10 per cent	6000	.003410
Total	$23,450	.013864
Total—less fixed charges	$17,450	.010454

Plant: Two 330-hp. engines, 440 kilowatts, cost per kilowatt, $137; production, 1,761,000 kw-hr. per year; load factor, 46 per cent; fuel oil cost, 6½c per gal.; lubricating oil cost, 50c per gal.; kw-hr. produced per gallon of fuel oil, 11.2.

Large Diesel Engines

In a second paper on The Economic Fields for Large Diesel Engines, Edward B. Pollister, general manager of the Busch-Sulzer Bros.-Diesel Engine Co., gave a number of instances of the use of large Diesel engines in various fields. He defined a large Diesel engine as one ranging from 2500 to 25,000 hp., the latter figure not yet being reached but being possible by the use of 10 cylinders of 900 mm. bore, each of which would give 2400 hp. at 110 r.p.m. As instances of large engines, he mentioned the 12,000-hp. Panama Canal power plant at Miraflores, and the 28,000-hp. plant on the motor ship Augustus.

As to the use of oil in an oil-burning steam plant or in a Diesel engine, estimate was given that at least half of the fuel oil would be saved, if Diesel engines were used rather than oil-burning boilers.

Based on actual selling prices of the few large Diesels that have been sold in this country, the cost is approximately that of modern steam plants. Spite of comparatively high former prices, large stationary Diesels cost less than $60 per hp. today and the total cost of a large Diesel generating station is normally around $135 per kw., made up about as follows for average conditions:

ESTIMATE OF COST OF A FOUR-UNIT, 15,000-B.HP., 10,000-KW. DIESEL INSTALLATION

Real estate	$ 10,000
Building, including 20-ton crane	75,000
Foundations	40,000
Four 3750-b.hp. Diesel engines, f.o.b. point of manufacture	900,000
Freight on engines at $1 per cwt.	40,000
Generators and exciters, direct-driven	100,000
Freight on generators and exciters	5,000
Unloading and placing on foundations	15,000
Erection	15,000
Station piping	15,000
Cooling-water system (if required)	25,000
Fuel storage	10,000
Switchboard and wiring	20,000
Miscellaneous items, contingencies, and engineering	80,000
Total	$1,350,000
Diesel station cost per kilowatt of installed capacity	$135

Diesel Engines as Auxiliaries

Advantageous use can be made in the following ways: For carrying normal peaks, permitting steam equipment to be operated at the most favorable load; for emergency peaks; for standby and reserve on high voltage lines; for auxiliary in hydraulic plants. Aside from normal daily peaks, occasional unexpected fluctuations, such as a clouding up on a bright day, can be easily taken care of by Diesel standby auxiliaries and it may frequently be the case, on a long high tension line, that the Diesel standby at the far end of the line will serve for surplus capacity during peak loads and be in readiness for emergencies, at less expense than a similar steam plant.

Another field is as auxiliary for hydro-electric plants during times of low water flow, since depreciation is small when the plant is shut down and the fuel can be safely stored for long periods.

Diesel Engine and the Public Utilities

This was the title of a paper presented by Roswell H. Ward, who carried further the idea expressed by the previous speaker, enlarging upon the public utility use of Diesel power, competition between the Diesel industry and the utility companies and competition for municipal projects. He listed the reasons for the acute situation as between Diesel engine salesmen and power salesmen and advocated accurate compilation of reports on Diesel power costs, checking of data to make sure that they were fair and unbiased and the interchange of data on private and public utility Diesel plants.

In the general discussion of these papers, Edgar J. Kates, Chairman of the Oil and Gas Power Division of the A. S. M. E., favored the use of the Diesel engine in small private plants, while P. H. Schweitzer, Associate Professor of Engineering Research of Pennsylvania State College, advocated the use of the Diesel engine for carrying peak loads in the central stations

L. H. Smith of the New England Power Co. at Worcester, Mass., felt that the inability to get large sizes of Diesel engines was the cause of lack of interest on the part of the utility companies. As to peak loads he stated that primarily a few weeks in winter were all that bothered now and that his company was meeting this situation by cutting out stage heating and passing all condensate through the condenser which would be done easily without loss of vacuum at winter cooling water temperatures.

Friday Morning Session

This was devoted to Diesel-fuel oil specifications, G. H. Michler of the Standard Oil Co. of New Jersey, pleading for uniform and simple specifications in order to reduce the cost of fuel oil. He gave examples of various specifications that his company had been asked to meet and showed by an illustrative example a case where an engine, designed for a heavy oil, gave trouble when working on a lighter and what seemed to be a better quality oil.

Mr. Michler advocated specifications simplified to cover three points: minimum gravity, sulphur content and flash, the minimum gravity being 24 deg., a.p.i.; maximum sulphur content 1.5 per cent and minimum flash of 150, which has generally been standard.

Commenting on this paper, Commander J. J. Broschek outlined Navy specifications drawn in 1925, which were for a flash not lower than 150 deg., water and sediment not greater than 0.5 per cent, sulphur not greater than 1.5 per cent, viscosity not greater than 200 sec. universal Saybolt, at 200 deg. F. and ash not greater than 0.1 per cent. The Navy discounted gravity specifications feeling that viscosity was a better index to the usefulness of the oil for its purposes.

With this J. W. Morton agreed, stating that sulphur content is not of great importance but that ash and asphaltum are very undesirable. Ash should not exceed 0.05 per cent because of its considerable wear and tear on moving parts.

In the first paper on co-operative Diesel engine research, Harte Cooke, engineer of McIntosh & Seymour Corp., gave a brief history of the development of the Diesel engine, showing that Doctor Diesel was interested primarily in a more efficient heat transformation and reduction of fuel costs and that the savings in operation due to lower labor cost per unit and lower maintenance were discovered after the engine was built.

Mr. Cooke brought out the development that has taken place in the 4 and 2-cycle air injection types, also in the solid injection and the wide use of Diesel engines for all classes of industrial work. Among the points which still need investigation are the nature of the combustion in the engine, characteristics of the products of combustion at the high temperatures and pressures obtaining in Diesel engines, more complete information regarding the transfer of heat from this mixture to the cylinder walls, and a co-ordination of information now existing as to the transfer of heat to the water jackets, also more complete knowledge of characteristics of walls and other parts to resist high temperatures and natural wear.

Progress is being made to a certain extent in the adaptation of the Diesel engine to aeronautics, the chief problems being fuel consumption, light weight and high speed.

Oil Spray Research

Following this, a paper by Professor Schweitzer was given on the Penn State oil spray research as to cutting down ignition lag, penetration of the jet spray into dense air, avoidance of dispersion and of dribbling. He estimated that fruition of results would be attained within a year. In discussion of this paper, W. F. Joachim, mechanical engineer at Langley Field, Va., outlined work covering similar ground which has been done at Langley Field in the effort to adapt the Diesel engine to aircraft. These studies have resulted in the reduction of pressures from 1600 lb. to 500 lb., per sq. in. initial, reduction of mean effective pressure to 112 lb., fuel consumption to 0.45 lb. per b. hp., with running speeds as high as 1500 r.p.m.

Saturday morning session was devoted to manufacturing problems with specialization advocated by O. D. Treiber who felt that the various parts required, such as bearings, piston rings, crank shafts, valves, cams, springs and the like can better be manufactured in plants specializing on these parts than in the engine plant.

Speaking on the manufacture of fuel injectors, C. R. Alden brought out the difficulties experienced in the manufacture of plungers and bushings and the fact that specifications are in some cases so rigid as to involve unnecessary cost. He showed a number of designs of plungers and bushings and explained how the design could be arranged so as to give lower manufacturing cost yet provide all needed accuracy and tightness.

Those in attendance at the session not only had a most enjoyable three days, but all agreed that worth while progress had been made in advancing the understanding and interest in the use of the Diesel engine.

Brazing Steel in Atmosphere of Hydrogen

BY THE USE of atmospheres of protective gas in electric furnaces, steel parts used in the manufacture of complicated assemblies can now be conveniently united by a strong alloy weld that would be exceedingly difficult to accomplish by other means, according to an announcement by the General Electric Co. This method, known as hydrogen brazing, involves the welding together of the parts to be joined by means of a copper flux.

Electric furnaces of small size, utilizing protective atmospheres, have been used in laboratories for brazing by this method for some years. An early and important use was the manufacture of steel shafts for golf clubs.

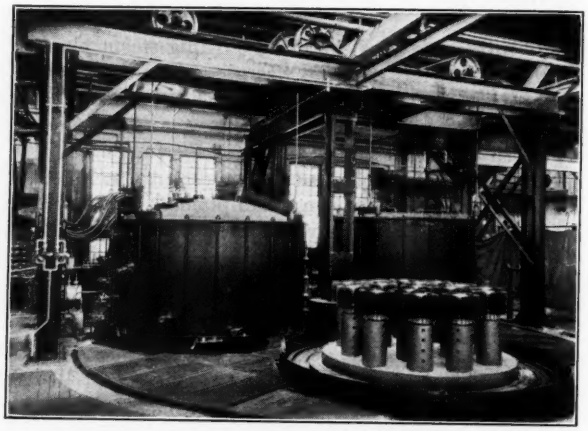


FIG. 1. HYDROGEN BRAZING FURNACE CONSISTS OF THREE STAGES

The advantages of the process were quickly recognized and a gradual development of suitable equipment followed. The theory of the process involves the reducing action of a hydrogenated atmosphere which thoroughly cleans the surfaces to be joined and the capillary attraction of the fluid copper, causing it to diffuse quite generally over the surface and to be drawn into the minutest joints between the parts. The protective atmosphere is essential during the cooling portion of the cycle also and for this reason the usual type of furnace cannot be used.

As used in the Schenectady plant of the General Electric Co., a typical hydrogen brazing furnace consists of three stages, Fig. 1. Each stage is in the form of a platform. Covers which may be raised and lowered are provided for two of the stages. The work to be brazed is first assembled on one stage, copper wire or chips being placed adjacent to the joints to be united. The assembly is then placed in the heating chamber at a suitable temperature and the next stage loaded. When the first assembly has been suitably heated over a predetermined period of time, it is withdrawn from the heating chamber and placed in a cooling chamber, the second assembly automatically moving into the heating chamber. Thus the heating, cooling and assembly may take place at the same time.

Another application on which the protective gas

envelope is used to advantage is bright annealing steel in sheet or fabricated form, for nickel, monel and certain other non-ferrous metals, to save the cost of annealing pots, handling, pickling, and so on. In such work, a furnace of the continuous type is used, designed for larger output. The work is loaded on suitable trays arranged to be pushed through the furnace on a roller track. An elevator raises the trays into the furnace at the entrance end and a similar elevator is used to remove them from the discharge end. A hydraulic cylinder is used to push the work through the furnace.

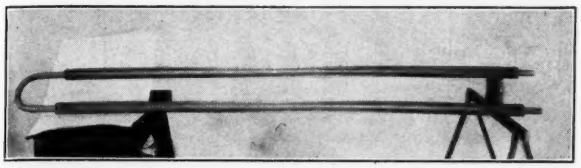


FIG. 2. FINS ON TUBES FOR HEAT TRANSFER EQUIPMENT ARE COPPER-BRAZED IN ELECTRIC FURNACE

Heating takes place in only one portion of the furnace, the remainder being provided with a water jacket for cooling; thus the work is both heated and cooled in the protective gas atmosphere.

Two-Pointer Draft Gage

FOR MANY purposes, such as uptake and furnace draft or pit pressure and furnace draft comparisons, it is desirable to have two simultaneous readings on the same gage. To meet this need, Ellison Draft Gage Co., 214 W. Kinzie St., Chicago, Ill., has added to its line a 2-pointer draft gage with two sets of gradu-

POINTERS GIVE SIMULTANEOUS READINGS FOR COMPARISON

ations on the same dial. The upper pointer is on a straight arm which swings above and in front of the scale. From the lower row of graduations, the arm swings back of the scale with a pointer coming up in front of the scale so that the pointers do not cross on the front side of the scale.

This gage is of liquid pan and bell type, using 42 deg. Be. kerosene. Draft connection is to the inside of the bell, which draws down one end of the weighted cross bar, swinging on steel knife edges, and swings the pointer against the gravity pull of the weights.

At one side of the casing is an opening with screw cap for absorbing the liquid level and filling the pan. allowable level range being indicated by top and bottom edges of a ¾-in. bar in the pan, which gives 1¼-in. liquid seal at low liquid level and top bell travel. Drainage is through an opening in the bottom of pan and casing, which is closed by a screw cap with lead seat.

The 10-in. white scale has large figures for distant visibility and is furnished with minus ranges of 1, 1½, 2, 3, 4 or 5 in. and with plus ranges up to 6 in.

Newark Testing Sieve of Improved Design

RECENT IMPROVEMENTS in design and construction of testing sieves are announced by The Newark Wire Cloth Co., 351 Verona Ave., Newark, N. J. A nest of the sieves is shown in the accompanying illustration.

Principal improvements are in the design of the inside corner, which is rounded instead of sharp to eliminate trouble sometimes caused by the mesh becoming

NEST OF 8-IN. TESTING SIEVES

filled with material. Besides this, all soldering is done on the outside instead of on the inside. The sieve is arranged so that when the wire cloth needs replacement the old solder can be melted off and a new piece of cloth soldered on without distorting the cloth. This arrangement is intended to preserve the accuracy of the cloth. The sieves are made in diameters of 3, 5, 6, 8, 10 and 12 in., and are in accordance with specifications of U. S. Bureau of Standards, adopted as standard by the American Society for Testing Materials in 1926.

High-Speed Diesel Drives Air Compressor

AIR COMPRESSOR belted to a high-speed Diesel engine is an interesting application of Diesel power recently introduced by The Buda Co., of Harvey, Ill. The compressor is of the horizontal type and the engine, a four-cylinder, 90 hp., solid injection Buda—M.A.N. Diesel operates at 950 r.p.m. A twin disc clutch is enclosed in a housing bolted directly to the flywheel enclosure and the engine is connected to the compressor by means of a short belt and idler pulley.

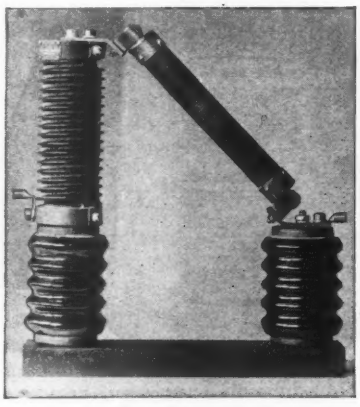
Air at 130 lb. pressure is delivered by the compressor at a rate of 400 c.f.m. The air is primarily intended for serving Harris air-lift pumps in deep well operation, raising the water from a depth of 167 ft. and delivering it to a storage tank.

Fuel with a gravity of 28 to 30 deg. Baume is supplied from storage tanks through a Niagara meter and a Zenith duplex filter is installed in the line to remove any foreign matter that may be in the fuel. The fuel consumption ranges from 0.40 to 0.45 lb. per br. hp.

Lubrication of moving parts is under a pressure of 45 lb. and the lubricant is passed through a filter before being re-used.

Combined Potential Transformer Fuse and Resistor

WESTINGHOUSE Electric and Manufacturing Co. announces a Type H combination potential transformer fuse and wire wound resistor for 2500 to 25,000-v. service. It is intended for indoor application and can be mounted on any flat surface or upon 1¼-in. pipe. The resistors are placed in series with the fuses and effectively limit the current in case of short circuit. This



TYPE H COMBINATION POTENTIAL TRANSFORMER FUSE AND WIRE-WOUND RESISTOR—FUSE MOUNTED AT ANGLE—FOR 15,000 V.

permits the use of potential transformer fuses on any circuit regardless of its short circuit amperes, provided the voltage rating of the system is not more than that of the fuses and resistors.

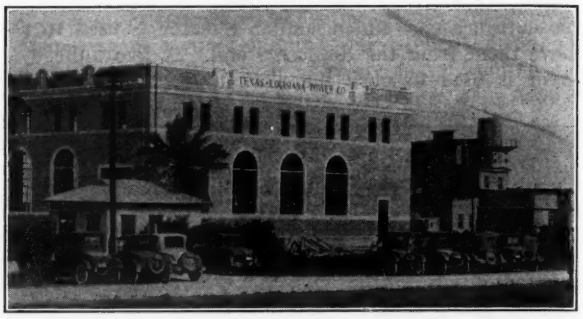
Combined with fuse, fuse mountings and insulators, as shown in the accompanying illustration, the resistors are made up of coiled nichrome wire wound in the grooves of a heavy wet-process porcelain tube. The resistor may be mounted either in line with or perpendicular to the insulators. This permits the apparatus to be adapted to space requirements.

Plant at Texas City to Have New Plant

TEXAS-LOUISIANA POWER Co., which recently purchased the power and lighting systems at Texas City and two adjoining towns, is completing, at Texas City, a new power house, as shown herewith. This plant will serve Texas City, Dickinson and League City; the company has also extended transmission lines into the rural district around League City and Texas City.

Port activities at Texas City, where approximately 30,000,000 bbl. of oil are handled annually by motor-driven pumps and a large electric crane is used to load bulk sulphur and similar commodities upon ships, will make a heavy demand upon the new plant.

Internal combustion engines will be used to generate power; the plant is designed on the twin unit plan, with half of each unit being held in reserve for emergencies.



PLANT AT TEXAS CITY NOW UNDER ERECTION

Plans also were made to allow for expansion of the plant by the addition of units. P. J. Hayes is superintendent for this district, where the Texas-Louisiana company is operating under the name of the Texas-Gulf Power Co.

Advance Program Announced for Second National Fuels Meeting

ALTHOUGH THE SECOND NATIONAL FUELS MEETING to be held in Cleveland, September 17-20 is still some distance away, the program committee is already in a position to announce a tentative list of speakers for the occasion. Present indications are that there will be twelve sessions of two papers each. The tentative program follows.

GENERAL

Opening Address—Thomas T. Baker, Pres., Carnegie Inst. of Tech., Pittsburgh, Pa.

Present Tendency of Boiler-Water Conditioning—R. E. Hall, Hall Laboratories, Pittsburgh, Pa.

Possible Avenues of Productive Research on Coals—F. R. Wadleigh, Con. Engr., New York, N. Y.

Progress Toward Direct Firing of Boilers with Producer Gas—W. B. Chapman, Cons. Engr., New York, N. Y.

Washing and Preparation of Coal—H. D. Smith, Asst. to Pres., Majestic Collieries Co., Bluefield, W. Va.

FUEL CHARACTERISTICS

Relative Values of Solid, Liquid and Gaseous Fuels—T. Ward, Mass. Inst. of Tech., Boston, Mass.

Constitution and Classification of Coal—A. C. Fieldner, Ch. Engr., Exp. Sta. Div., U. S. Bureau of Mines, Washington, D. C.

Fuels and Their Flame Characteristics with Reference to Combustion Values and Furnace-Space Requirements—Henry Kreisinger, Research Engr., Combustion Engrg. Corp., New York, N. Y.

INDUSTRIAL

Industrial-Furnace Efficiency Economic Considerations—Jas. H. Herron, Cleveland, O.

The Use of Fuels in Tunnel Kilns—W. E. Rice, U. S. Bureau of Mines, Pittsburgh, Pa.

MARINE

Pulverized Coal Firing of Marine Boilers.

Stoker Firing of Marine Boilers.

Oil Firing of Marine Boilers.

Power Plant

Recent Developments and Improvements in the Baffling of Vertical Boilers—A. O. Danks, Cleveland, Ohio.

Texas Lignite as Fuel for Power-Plant Boilers—Hal C. Weaver, Prof. M. E., Univ. of Texas, Austin, Tex.

Stoker Advantages and Difficulties—Theo. Maynz, Cons. Engr., Cleveland, Ohio.

Developments in Recent Design of Stoker-Fired Equipment—Jos. G. Worker, Asst. to Pres., American Engrg. Co., Philadelphia, Pa.

Boiler-Furnace Refractories—C. P. Hirshfeld, Ch. Research Dept., and W. A. Carter, Tech. Engr., Power Plants, Detroit Edison Co., Detroit, Mich.

Determination of Economic Value in the Selection of Power-Plant Equipment—F. M. Van Deventer, M. E., Constr. Dept., Henry L. Doherty & Co., New York, N. Y.

Pulverized Fuel

Progress in Central-Station Use of Pulverized Coal—Edw. H. Tenney, Ch. Engr. Power Plant, Union Elec. Light & Power Co., St. Louis, Mo.

Present Status of Furnace and Burner Design as Affected by the Use of Pulverized Fuel—E. G. Bailey, Pres., Fuller Lehigh Co., Fullerton, Pa.

The Present State of the Art of Collecting Dust from Chimney Gases in Powdered-Fuel Installations—Kurt Toensfeld, Research Engr., Combustion Engrg. Corp., New York, N. Y.

Unit System of Coal Pulverizers—John Blizard, Head, Research Dept., Foster Wheeler Corp., New York, N. Y.

Railroad

Railway Practices in Utilization and Conservation of Oil—J. M. Clark, Ch. Fuel Supervisor, So. Pac. R. R. Co., San Francisco, Calif.

Relative Values of Different Sizes of Same Fuel in Locomotive Service—John J. Crawford, Fuel Engr., C. B. & Q. R. R. Co., Chicago, Ill.

Selection and Use of Fuels in Locomotive Practice—Malcolm McFarlane, N. Y. Central R. R. Co., New York, N. Y.

Railway Practices in Utilization and Conservation of Coal—W. J. Overmire, Fuel Engineer, Big Four R. R. Co., Indianapolis, Ind.

Smoke Abatement

The Measurement of Atmospheric Smoke Pollution—A. S. Langsdorf, Acting Dean Engrg., Wash. Univ., St. Louis, Mo.

Smokeless and Efficient Firing of Domestic Furnaces, Part II—Victor J. Azbe, Cons. Engr., St. Louis, Mo.

Problems and Methods in Smoke-Abatement Work—H. K. Kugel, Deputy Smoke Commr., Cleveland, O.

Damage Due to Smoke and Smoke-Abatement Methods—H. B. Meller, Commr. of Smoke Inspection, Pittsburgh, Pa., and Dir., Smoke-Abatement Res., Mellon Institute of Tech.

This year's meeting is under the auspices of the Cleveland Section of the A. S. M. E. and Victor J. Azbe is chairman of the executive committee of the Fuels Division, while Elliott H. Whitlock is chairman of the General Arrangements Committee for the meeting. Further details can be obtained from H. M. Hammond of the Publicity Committee at 150 Ivanhoe Rd., Cleveland, Ohio.

Charles A. Moore, Jr., president of Manning, Maxwell and Moore, Inc., 100 E. 42nd St., New York, has announced the purchase of the American Schaeffer and Budenberg Corp. of Brooklyn, New York and Worcester, Mass., from Ralph Jones and his associates. The newly acquired company was founded in 1851. The business of this company will be co-ordinated with that of the Consolidated Ashcroft Hancock Co., Inc., owned by Manning, Maxwell and Moore, Inc. The latter organization, which has operating plants in New England and the Middle West, will take over the operation of the Brooklyn and Worcester factories of American Schaeffer and Budenberg Corp. at once.

News Notes

In connection with the Convention of the National Association of Power Engineers in Detroit, September 10 to 15, a special lake trip on one of the large steamers of the Chicago, Duluth & Georgian Bay Transit Co. is planned for the benefit of the delegates sailing from Chicago. After a 3-day trip on the Great Lakes, the ship will dock at Detroit and its passengers will live on board during the entire convention instead of going to hotels in town. Return trip will be made to Chicago immediately after the convention.

National Safety Council will hold its 17th Annual Safety Congress in New York City, Oct. 1 to 5, with sectional meetings to discuss accident prevention in various industries. Public Utilities meetings will be held in Hotel Pennsylvania, starting Tuesday morning, Oct. 2. Details of the program will be available later.

It is announced that the Seventh National Exposition of Power & Mechanical Engineering is to be held December 3 to 8, 1928, in New York. Four floors of the Grand Central Palace will again be used for the exhibits, which will include, besides the power plant equipment, many displays of heating and ventilating apparatus, mechanical transmission equipment and material handling apparatus.

R. F. Schuchardt, Electrical Engineer, Commonwealth Edison Co., Chicago, was elected president of the American Institute of Electrical Engineers for the year beginning August 1, 1928, as announced at the Annual Meeting of the Institute held in Denver, June 26, during the Annual Summer Convention of the Institute. Other officers elected were: vice-presidents, E. B. Merriam, Schenectady, N. Y.; H. A. Kidder, New York City; W. T. Ryan, Minneapolis, Minn.; B. D. Hull, Dallas, Tex.; G. E. Quinan, Seattle, Wash. Directors, A. E. Bettis, Kansas City, Mo.; J. Allen Johnson, Niagara Falls, N. Y.; A. M. MacCutcheon, Cleveland, Ohio. National treasurer, George A. Hamilton, Elizabeth, N. J. (re-elected).

American Engineering Co., Philadelphia, Pa., announces that the Institution of Engineering and Shipbuilders of Scotland has awarded a premium to Joseph G. Worker, assistant to the president of the company, for his paper on "Use, Improvements and Test Results of the Multiple Retort Underfeed Stoker in the United States," read last year before the institution. An abstract of this paper appeared in the June 1, 1927, issue of Power Plant Engineering.

Flexitallic Gasket Co., 924 N. 8th St., Camden, N. J., announces the appointment of Warren & Bailey Co., 214 E. 3rd St., Los Angeles, Calif., as its exclusive distributor for Southern California, and Thomas Skinner of Vancouver, B. C., for Western Canada.

M. B. Skinner & Co., Chicago, Ill., announces that on May 1 it went into production at its new manufacturing plant at South Bend, Ind. The new plant is of the latest mill type construction, of colored face brick outside with vitrified white brick inside. It has a floor area of 26,500 sq. ft., as contrasted with 14,600 at the old Chicago plant. Beginning September 1, the main office of the company as well as the factory will be at South Bend. The plant is erected in an industrial sub-

division which is carefully laid out with suitable landscaping and great care has been taken in landscaping the grounds of the new Skinner plant to make it fit its attractive environment. No changes are contemplated in production or products of the company, nor in distribution methods used to handle them through the jobber.

A. B. BENSON, formerly secretary and treasurer of Conveyors Corp. of America, has been appointed general manager of Joseph Harrington Co., subsidiary of Whiting Corp., Harvey, Ill. Mr. Benson's experience has been largely in the power plant field. His appointment will relieve Joseph Harrington, president, of much detailed administrative work and permit him to devote more of his time to the engineering features of the business.

J. J. P. MACKENZIE, formerly assistant engineer in the Engineering Products Division of the Walworth Co. at New York, has been transferred to The Walworth Ohio Co., Cleveland, as manager of the Engineering Sales Department. Mr. Mackenzie took his M. E. degree in Scotland and was employed by a New York public utility corporation before joining the Walworth forces about 3 yr. ago. He has specialized in steel valves and fittings for high-pressure, high-temperature service.

GEORGE CLINTON WARD, executive vice-president of the Southern California Edison Co., received the honorary degree of Doctor of Science at Oberlin College on June 19. This degree has been awarded only eight times by Oberlin and was conferred on Dr. Ward in recognition of his work in applying the results of scientific research to the field of electrical and mechanical engineering.

CHICAGO PNEUMATIC TOOL CO., 6 E. 44th St., New York City, announces the appointment of George J. Lynch, formerly assistant district manager of the New York office, as district manager of sales at 1931 Washington Ave., St. Louis, Mo.

CHAIN BELT CO., Milwaukee, Wis., announces that Charles H. Upson has joined its sales organization with headquarters at Cincinnati. Mr. Upson, for the past 23 yr., has been District Manager for the Dodge Mfg. Co.

HARRY P. DEMPSEY, Consulting Engineer, 232 Delaware Ave., Buffalo, N. Y., announces that Howard S. Schall has become associated with him in his engineering practice.

GULF REFINING CO., 21 State St., New York City, has plans for a new refinery, storage and distributing plant at Mariners Harbor, Staten Island. It is understood that the plant will include a power house, pumping plant, conveying equipment and material handling equipment. The entire project is reported to cost about $15,000,000. William M. Braybrooks is general manager.

ARMOUR & CO., Union Stock Yards, Chicago, Ill., announces that J. F. McGillivray, after 15 yr. of service in the engineering division of the company, has resigned to form a company with E. V. Brady, formerly of Armour & Co., to specialize in industrial research and power economy service under the firm name of Tri-R-Service, 5254 W. Monroe St., Chicago. For the past 5 yr., Mr. McGillivray has specialized in work of this type for Armour & Co. and in his new connection proposes to suggest to industrial concerns and other users of power methods whereby they can reduce operating costs by methods similar to those he has been using. The service will deal only with the smaller types of installations, such as hotels, restaurants, laundries, bakeries and small plants and, on this account, it is stated, is new in the engineering field.

VREELAND TOMPKINS, president of the Smooth-On Manufacturing Co., was awarded the honorary degree of Master of Science at the commencement exercises of Rutgers University. The degree was conferred for distinguished accomplishment as a chemist and inventor.

NAYLOR SPIRAL PIPE CO., 1230 E. 92nd St., Chicago, Ill., announces that with the completion of its new plant, the name of the company has also been changed to the Naylor Pipe Co.

IN THE JULY ISSUE of the General Electric Review, Prof. Frank P. McKibben lists a total of 85 welded structures, including 43 welded buildings. The list includes 8 bridges, 43 buildings, 3 cars, 2 cranes, 6 frames and towers, 12 ships and allied structures and 11 tanks.

WESTINGHOUSE ELECTRIC & MANUFACTURING CO., has secured a contract from Alabama Power Co., Birmingham, Ala., for two 29,000-kv.a. vertical waterwheel generating units for its hydro-electric development now under way near Tallassee, Elmore County, Ala. The Lexington Water Power Co. has also ordered from Westinghouse four waterwheel generators of similar type, each of 40,825-kv.a. rating, to be used at its hydro-electric project on the Saluda River, near Columbia, S. C.

Books and Catalogs

MATTER, ELECTRICITY, ENERGY; the principles of Modern Atomistic and Experimental Results of Atomic Investigations, by Walter Gerlach; translated from the second German Edition by Francis J. Fuchs; cloth, 6 by 9 in., 139 pages, illustrated. D. Van Nostrand Co., Inc., 8 Warren St., New York City, 1928; price, $6.00.

In presenting this translation of Professor Gerlach's excellent work, the translator has been actuated by a desire to make this clear survey of recent developments in the field of atomistic available for those who, because of their lack of German, are unable to peruse the book in the original. The work is a scientific treatment of atomistic fundamentals successfully presented without the aid of technical mathematics and phraseology. It has an appeal for that great group of scientists whose activities overlap the field of physics. The book establishes the inter-relation of chemistry, minerology, astrophysics and the allied fields of scientific thought with pure physics.

The subject matter is made up of a series of independent lectures closely woven into a homogenous whole. The author has not attempted to deal with the whole field of atomistics but has, instead, selected certain recent developments which seem best suited for the purpose of giving the reader a clear understanding of general atomistics and to stimulate further searches on his part.

Beginning with a brief survey of general atomistics, which leads up to a study of isotopy and atomic rays, there are discussions of the formation and recognition

of these rays and of their uses. Rutherford and Petterson's researches on atomic disruption are fully described. Other sections of the book are devoted to the relationship between Bohr's magneton and Weiss' magneton, the former's work on line and x-ray spectra, the "Compton effect", resonance and dispersion, electromagnetic spectra, infra-red spectra, the photoelectric effect, photoelectric photometry, and spectrophotometry.

Considerable space has been given to photochemical studies and their physical background, to illuminescence in chemical reactions, photochemical catalysis, and radiation measurements.

This book is meat for the natural scientist, the physicist, the philosopher and for all those interested in application of physical concepts to scientific endeavor.

FIXATION OF ATMOSPHERIC NITROGEN, by F. A. Ernst, 6 by 9 in., 154 pages, illustrated; D. Van Nostrand Co., Inc., New York; cloth, $2.50.

Clear description is given of the reasons for fixation of nitrogen and comparison of cost, used as fertilizer, with the natural nitrates from Chile. The chemical reactions and commercial methods for the arc, the cyanamide and the direct synthetic ammonia processes are given, also comparison of investment required and power needed for each. Economic considerations are discussed, including the possibility of future developments. The investment cost, $400 per ton annual output, and the power required, 14,000 kw.-hr. per ton of fixed nitrogen for the cyanamide process, the one for which Muscle Shoals is equipped, are compared with investment cost of $240 a ton and power required of 3000 kw.-hr. a ton by the direct synthetic process with water-gas hydrogen. Present plants and their output are listed as well as the by-products.

The book gives a good understanding of the present status of nitrogen fixation, future probabilities and the processes involved.

POWER'S PRACTICAL REFRIGERATION, compiled by L. A. Morrison; second edition, cloth, size 6 by 9 in., 260 pages, illustrated. McGraw-Hill Book Co., Inc., 370 7th Ave., New York City, 1928; price $2.50.

This is primarily a book dealing with the practical side of refrigeration yet still includes the essential laws covering the production of refrigeration. It begins with a chapter on elementary refrigeration covering the action of ammonia, the condenser, the theory of superheating and the reason for using compressor.

Next in order are taken up the evaporating system, the compressor and condenser. This is followed by a chapter on installing refrigerating machinery, giving instructions as to how to buy, drawing up specifications in regard to the various equipments used in the ice plant. The absorption refrigerating system and the carbon dioxide refrigeration are discussed in individual chapters.

At the end of the volume is a chapter on testing. Considerable space has been devoted to the subject of indicating the ammonia compressors since it is thought a more general use of the indicator would do much to improve the efficiency of operation.

USES OF SPEED RECORDERS on various types of turbines, engines and industrial machinery are discussed in an illustrated 8-page bulletin, published by The Esterline-Angus Co., Indianapolis, Ind.

BACK-PRESSURE and relief valves and balanced valves of various types are described and illustrated in Bulletin No. 203, sent out by Illinois Engineering Co., Racine Ave., 20th Pl. to 21st St., Chicago.

ARTICLES on "Co-operative Apartments, Why Not Co-operative Heating?" and on "District Heating in Small Communities" are of particular interest in No. 3, Vol. II, of the Adsco Advocate, recently received from American District Steam Co., North Tonawanda, N. Y.

ENGELHARD AUTOMATIC Temperature Control is described in a 6-page illustrated leaflet issued by Charles Engelhard, Inc., 90 Chestnut St., Newark, N. J.

HEAVY DUTY CORLISS and drop piston valve engines are illustrated and described in detail in a 20-page bulletin, 1529-C, issued by Allis-Chalmers Mfg. Co., Milwaukee, Wis.

DIESEL ENGINES for central stations are described in Bulletin 118 just issued by McIntosh & Seymour Corp., Auburn, New York. Data on various installations are given, together with performance figures and comparisons of heat consumption of various types of prime movers. Details of the engines are well described and illustrated.

ADSCO VARIATORS, which are packless expansion joints for inaccessible steam lines, are discussed in a 4-page folder sent out by American District Steam Co., North Tonawanda, New York.

ALLOY STEEL for boiler construction is described in a recent 12-page bulletin No. 12 sent out by International Nickel Co., Inc., 67 Wall St., New York, N. Y.

WHICH DO YOU PREFER is the title of a new bulletin comparing the Turner baffle wall with the Beco baffle wall. This bulletin is issued by the Boiler Engineering Co., 931 Federal Trust Bldg., Newark, N. J.

REPORT ON RATING CODE by the Committee on rating and selection of low-pressure heating boilers of the American Society of Heating & Ventilating Engineers, 29 W. 39th St., New York City, has just been received.

SEVERAL EXAMPLES of attractive substations are illustrated in the June 15 issue of The Delta Star, published by Delta Star Electric Co., Fulton St., Chicago, Ill.

E C & M Type ZO switches for across-the-line starting are described in a 4-page leaflet by Electric Controller & Mfg. Co., Cleveland, Ohio.

INSULATION OF BREECHINGS and stacks is discussed in bulletin 141 just published by Celite Products Co., 1320 Hope St., Los Angeles, Calif.

LUBRICATION for Safety and Economy by the use of Houghton's absorbed oils and Gun-Fil lubricators is discussed with details of equipment and applications in an 18-page booklet published by E. F. Houghton & Co., Philadelphia, Pa.

VOYAGE OF THE MERCER, the first ship to cross the ocean under power generated from pulverized coal, is described in detail in a 12-page illustrated booklet sent out by Kennedy-Van Saun Mfg. & Engrg. Corp., 2 Park Ave., New York City.

Power Plant Construction News

Ala., Mobile—The General Cable Co., 114 Liberty Street, New York, will install power equipment in a proposed new plant at Mobile, site recently acquired, entire project reported to cost more than $200,000.

Calif., Los Angeles—The Diamond Hardwood Flooring Co. plans installation of power equipment in connection with proposed rebuilding of portion of mill recently destroyed by fire with loss of about $100,000.

Calif., South San Francisco—The Pacific Coast Steel Co., San Francisco, will install power equipment in connection with proposed extensions in plant at South San Francisco, entire project to cost in excess of $500,000.

Conn., New Britain—The Fafnir Bearing Co. will install power equipment in a proposed six-story addition to its ball bearing plant, estimated to cost in excess of $150,000.

Conn., Waterbury—The Farrel Foundry & Machine Co., Bank Street, will install power equipment in proposed three-story addition to its plant to cost more than $100,000 with equipment. Fred A. Webster, Waterbury, is architect.

Ga., Moultrie—Swift & Co., Union Stock Yards, Chicago, Ill., meat packer, has approved plans for a cold storage and cooler addition to local packing plant, estimated to cost about $100,000, with equipment.

Ill., Chicago—The Sisters of Resurrection Academy, care of Sandel & Strong, 10 East Huron Street, architects, have filed plans for a one-story boiler plant and mechanical laundry at proposed new addition to convent, entire project to cost about $300,000.

Ill., East St. Louis—Darling & Co., Inc., East St. Louis, will install power equipment in a proposed one-story addition to fertilizer plant estimated to cost about $100,000.

Ind., Evansville—The Evansville Ice & Cold Storage Co., 10 North Eighth Street, has asked bids on general contract for a new two-story cold storage and refrigerating plant, reported to cost in excess of $40,000, with equipment.

Ind., Muncie—The Warner Gear Co. will install power equipment in two new plant additions to cost about $130,000, and for which superstructure will soon begin.

Ind., Winslow—The Electric Shovel Coal Corporation, Clinton, Ind., will install an electric-operated coal-mining plant, including steel tipple, at properties at Winslow, recently, acquired, reported to cost more than $150,000.

Iowa, Marshalltown—The Marshalltown Trowel Co. plans installation of power equipment in a proposed new plant addition to cost in excess of $100,000 with machinery.

Iowa, Waterloo—The John Deere Tractor Co. will install power equipment in a group of new plant units reported to cost in excess of $375,000, with equipment.

Kans., Coffeyville—The Page Milk Co., Merrill, Wis., is considering the construction of a boiler plant at its proposed local milk condensory, entire project to cost about $175,000.

Ky., Maysville—The Maysville Water Co., is planning an expansion and improvement program in plant and system, and proposes to issue bonds for the work, to include installation of pumping machinery and other power equipment, filter plant apparatus, etc. H. J. Cochran is president.

La., Shreveport—The Southwestern Gas & Electric Co., Shreveport, has approved plans for the construction of a transmission line between Shreveport and Marshall, by way of Jefferson, to operate at 66,000 volts, and will soon begin work.

Md., Baltimore—The Tidewater Oil Co., 11 Broadway, New York, plans installation of boilers and other power equipment in connection with proposed oil storage and distributing plant in Curtis Bay section estimated to cost more than $350,000.

Md., Baltimore—The Asiatic Petroleum Co., Ltd., 65 Broadway, New York, will install power equipment in a proposed new refinery and distributing plant on local site, recently acquired; entire project will cost close to $1,000,000.

Mich., Pontiac—The Oakland Motor Car Co., a division of the General Motors Corporation, Detroit, will install power equipment in proposed new group of six buildings, reported to cost in excess of $500,000, with machinery.

Minn., Minneapolis—Waldron, Inc., Eleventh Street and LaSalle Avenue, plans installation of boiler and power equipment in a proposed mechanical laundry plant at Twenty-fourth Street and Lyndale Avenue, to cost about $200,000. Long & Thorshov, Andrus Building, are architects. M. B. Waldron is president.

Miss., Lexington—The Mississippi Power & Light Co., Jackson, has approved plans for immediate construction of new power substation at Lexington, reported to cost in excess of $30,000 with equipment.

Mo., St. Louis—The LaClede Packing Co., 2025 Shenandoah Street, will make extensions and improvements in boiler plant at branch factory at Lucky and Prairie Streets, estimated to cost more than $25,000.

Mont., Helena—The Helena Waterworks Co. plans installation of new pumping plant in connection with extensions in system.

N. J., Carlstadt—The Koeppen Metal Products Co., 361 Manhattan Avenue, Union City, N. J., plans installation of power equipment in proposed new plant at Carlstadt, entire project reported to cost close to $90,000. Site has been purchased.

N. J., Linden—The American Cyanamid Co., 535 Fifth Avenue, New York, plans installation of boiler plant and factory power equipment in proposed new plant at Linden for production of agricultural chemicals. Company will also expand plants at Warners, N. J., and Niagara Falls, Ont., entire project to cost more than $2,000,000.

N. Y., Firthcliffe—The Firth Carpet Co. will install power equipment in a new five-story yarn mill addition, estimated to cost more than $160,000. Lockwood, Greene & Co., 100 East Forty-second Street, New York, are architects and engineers.

N. Y., Niagara Falls—The Carborundum Co., Buffalo Avenue, will install power equipment in a new five-story addition to its abrasive plant estimated to cost more than $100,000. L. J. Call is company engineer.

Ohio, Cleveland—The Otis Steel Co. will install power equipment in proposed new additions to Riverside plant on Jennings Road, reported to cost more than $250,000.

Ohio, Zenia—The Board of Directors, Wilberforce University, has plans under way for the construction of a new central power plant at the institution to cost about $120,000, of which approximately $65,000 will be expended for equipment. Herbert B. Briggs, Ohio-Hartman Building; Columbus, Ohio, is state architect in charge.

Okla., Guthrie—The Board of Utility Commissioners plans installation of a pumping plant in connection with extensions and improvements in the municipal waterworks. The Benham Engineering Co., Gumbel Building, Kansas City, Mo., is engineer.

Okla., Norman—The New State Ice Co., West Third Street, Oklahoma City, Okla., is said to be planning construction of one-story ice-manufacturing plant on local site, estimated to cost about $70,000, with equipment.

Pa., Mt. Carmel—The Susquehanna Collieries Co., Commercial Trust Building, Philadelphia, Pa., has approved plans for the electrification of its local Cameron Colliery, reported to cost more than $40,000 with equipment.

S. C., Goldville—The Joanna Cotton Mills, Inc., will install power equipment in a new three-story and basement addition estimated to cost in excess of $200,000, for which plans have been approved. Lockwood, Greene & Co., Charlotte, N. C., are engineers.

Tenn., Knoxville—The Atlantic Ice & Coal Co., 106 Collins Street, S. E., Atlanta, Ga., is planning construction of new ice-manufacturing plant on local site to be equipped for initial capacity of 125 tons per day; a cold storage plant is also contemplated. Entire project is estimated to cost more than $150,000, with equipment.

Va., Bedford—The Bedford-Johnson Co. will install power equipment in a new woolen mill on local site, for which plans have been approved, reported to cost more than $175,000. J. E. Sirrine & Co., Greenville, S. C., are engineers.

Wash., Yakima—The Oregon Packing Co., Portland, Ore., will build a one-story boiler plant at a new canning factory on First Avenue South, Yakima. Entire project to cost about $40,000.

Wis., Kohler—The Kohler Co. plans installation of power equipment in new addition to its pottery to cost about $100,000. Plans are being completed.

Wis., Waukesha—The Waukesha Motor Co., West St. Paul Avenue, plans installation of power equipment in proposed new additions to cost close to $500,000. Samuel Perkins is president.